

The AMSAT[®] Journal

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EA4LE*

A FIRST TRY: LAUNCHING UNAMSAT-1 FROM PLESETSK, RUSSIA: A TRAVELOGUE

**by David Liberman, XE1TU, UNAMSAT Project Director, Universidad
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Editor's Note: UNAMSAT-1, a microsat similar in design to AO-16, IO-26, LO-19, and WO-18, was developed by UNAM and launched from Plesetsk, Russia on March 28, 1995. Presently the UNAM team is trying to secure a launch opportunity for the already constructed UNAMSAT-B. This article provides a unique insight into the efforts of launching an amateur satellite when facing diverse language, cultural, and climatic differences. Many thanks to David for taking the time to chronicle and share a very interesting experience with AMSAT Journal readers!

Mexico City, Mexico

The UNAMSAT-1 launch campaign started in the last week of February, 1995. A list of all required operations was produced to help keep track of all needed procedures. It was incredible to see the amount of little details still pending after seven months of continuous satellite operation on the table in a clean room, especially when we all knew that it was "ready".

A packing list also had to be produced. Using AMSAT specifications for traveling boxes used for the microsats launched by Ariane, we had a Mexican company construct similar boxes for all the gear we were taking to Moscow. There were compartments for each instrument including the oscilloscope, spectrum analyzer, multimeters and tools. We also carried a box with resistors, capacitors, transistors, etc., and a soldering iron and special low resin solder, just in case we had to make some repairs at the last minute. I remembered Tom Clark, W3IWI, telling me that there were no Radio Shack stores in Moscow, and that we'd better make sure we take all the things we could possibly need, otherwise we could be in trouble. He also suggested taking connectors because the Russian connectors, like the PL-259 or N look very similar but do not fit. So we had a bundle of all the connectors we could require and more. I

[continued on page 5]

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Apogee View

How Are We Doing?

by Bill Tynan W3XO

All of us knew when we committed to the Phase 3D Project that it would be the most daunting endeavor that amateurs had ever attempted. We were not wrong. It has proven to be a monumental effort from all standpoints - technical, managerial and fiscal. This is true, not only because Phase 3D is the most sophisticated spacecraft that has ever been attempted by an organization not directly connected with a commercial company, government or major university, but the fact that it is an undertaking involving participants from some dozen countries around the world. This would be, of course, one of its strengths as well as one of the factors that make managing it challenging. I thought that this is a good time and place to bring our members up to date on the status and prospects for the Project.

As all of you know by now, the spaceframe was completed and delivered last summer. Many of you saw it personally during our Annual Meeting and Space Symposium in Orlando last October. You will get another chance to view progress this October. The dates are the 6th, 7th and 8th and the place is again the Airport Holiday Inn in Orlando. You have also seen many pictures of the spaceframe both here in the AMSAT Journal and in other amateur publications, including QST. In fact, our spacecraft was featured on the cover of the May issue of that magazine, along with the lead article by Steve Ford, WB8IMY. Naturally, we appreciate the coverage that ARRL and other Amateur Radio publishers have given the Project. We also are indebted to the League for their former and current fundraising efforts. But, more on that later.

The other major mechanical task completed has been the construction of the Specific Bearing Structure or SBS. This is the cylinder in which P3D will be contained during its ride on the Ariane launch vehicle. The SBS is a very critical component of our effort because it not only houses our spacecraft, but must also support whatever

the European Space Agency may want to place on top of us as a paying passenger. When one considers that "paying" means fees in the order of FIFTY to ONE-HUNDRED MILLION DOLLARS for rides for satellites valued at perhaps twice that amount, you can see how important the SBS is to P3D's getting a ride on Ariane. Since we have designed and built the SBS, we must prove that it will adequately support a 4.7 ton satellite under the 7 G launch loads that the Ariane will impose on all of its payloads. Doing so, represents one of our major challenges. It may require the construction of a second SBS for which we have the materials on hand. We are currently investigating this option.

Many other things have happened to the spaceframe. RF and power wiring are almost complete. Signal wiring will be completed soon. The mounting for the main battery has been completed and installed and the one for the auxiliary battery will be in place by the time you read this. Similarly, the brackets that will hold the liquid propulsion motor have been completed and installed. A myriad of other smaller mechanical items have been fabricated and installed as well.

Final designs for the flight antennas are well underway and should be complete and ready for installation on the upper and lower plates by mid-summer.

Designs for the various computers have been finalized and checked out. Construction of the flight hardware is now a relatively routine matter and should be completed in a few weeks. This includes the main spacecraft computer, the IHU, the RUDAK and the computer associated with the GPS subsystem. The RF portion of the GPS flight hardware is also in the final stage of fabrication.

Reports from Europe indicate that most of the electronic subassemblies have been completed and checked out. Similar information has been received regarding the JAMSAT camera experiment. So, sometime this fall, we expect to start putting all of this together and testing the entire system.

Yes, this is behind our original schedule by a couple of months. But the slip has not been as serious as one might think. Reports in the space press state that the launch of the first Ariane 5 is now set for January 1996, rather than November of this year. These same reports place the launch of Ariane 502, on which we have been manifested for several years, as "late May 1996". As this was being written, we have been informed by an ESA official that the date is May 29, 1996. The schedule that ESA had provided heretofore called for a launch on April 3, 1996. Thus it appears that the slips in Ariane's schedule and ours are approximately in sync.

The funding side of the Project is about on track. Since we began our fundraising effort in late 1991, AMSAT-NA has raised well over \$400,000 from its own members. As reported previously, the ARRL's first campaign produced almost \$200,000. That money is allocated to go toward the launch fee and will be used for that purpose as soon as necessary. As you know from the May QST, the League has begun another campaign. The ARRL Board authorized it at their January meeting and backed up their commitment with a pledge to match all contributions received up to \$150,000. This latest effort is going very well. According to the ARRL Letter dated June 20, contributions of over \$112,000 had been received as of June 15. As reported in Dave Sumner's "It Seems to Us..." editorial in the July QST the Southern Michigan Amateur Society has agreed to forego dues for this year and make contributions in the name of each individual member to the League's Phase 3D Fund. This is a fine move on the part of SMARS and it is hoped will serve as an inspiration for other clubs. If so, amateur clubs could well represent a major source of funding for the Phase 3D Project.

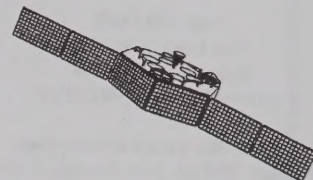
The Europeans have raised a considerable sum of money as well and are applying it to their various commitments in the Project; including batteries, solar cells, the reaction wheels, transmitters, receivers and the IF matrix.

At the same time, we are stepping up our own efforts. I have recently appointed Harwood Sheppard AA7MH of Prescott, Arizona as our new Vice President for Development. Shep has good contacts in corporate circles and will concentrate on raising funds from that source. I have also

been informed by a prominent amateur, who I know, that the foundation with which he is associated will match Phase 3D contributions made to AMSAT-NA during the rest of 1995, up to \$50,000. At the moment, he can not allow me to reveal the identity of the foundation, but I assure you that it is reputable.

So, all aspects of the Phase 3D Project are going well. While it is not quite as far along at this time as we had planned, that does not represent an insurmountable problem. But, there is a lot more to be accomplished, including the testing which must precede launch. Fundraising is going

well, but that is no reason to assume that more money is not needed. We are now in the expensive part of the Project and money is currently going out a lot faster than it is coming in. This situation is certain to continue right up through launch. Now is not the time for anyone to sit on their hands and think that the job is done. ■



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SP220VD	220-225	<1.9	15	0	DGFET	\$59.95
SP220VDA	220-225	<1.3	15	0	DGFET	\$67.95
SP220VDG	220-225	<0.55	20	+12	GaAsFET	\$109.95
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[UNAMSAT-1, Continued]

now know the reason why they don't fit. Russian connectors are metric; they look similar, and as for the impedance, they have the same diameter relations, but because they are manufactured in metric sizes, they don't match ours.

When preparing for the flight to Moscow, I heard one of my students complaining about all the stuff we were carrying. He said, "It is going to be very hard for us to carry all of these boxes, besides carrying our own luggage."

Another student replied, "Don't worry, we will not need all this."

Then the first student said, "If so, why should we carry it?"

The second student replied, "Because if we don't take it, we will need it!"

It was at that moment that I realized that some of my students had begun to understand space technology.

The days of preparation for our departure were passing by very fast and there were hundreds of things still to be done. Little by little, our list of things to do grew smaller, allowing us to start closing different shipping boxes. Two days before departure, we finished packing everything including the two satellites, tools, and parts. The students had designed a power supply to be connected to a 220V Russian power line for charging the satellite. Based on a HC6805 microprocessor that sensed the condition of the charging line and the battery voltage, it was fully automatic and kept the batteries fully charged. We were told that a Russian soldier would be put in charge of watching this power supply. This is why we decided to make it fully automatic, as we did not want the guard to have any switches or controls to move. Because we felt the guard may become very bored, we decided to give him a little beet for his amusement. There were two LEDs, one yellow and one green, to indicate whether the power supply was charging or standing by, and a line of 16 red LEDs that were lighted on sequence at a speed that we adjusted to be as catatonic as possible. While I do not have any reports the guard probably became very sleepy watching this power supply!

On the morning of Wednesday, March 15th, UNAM students and personnel arrived very early at the laboratory and loaded the UNAMSAT equipment into two trucks. Meanwhile, the rest of us went directly to the airport where we met with Aeroflot personnel

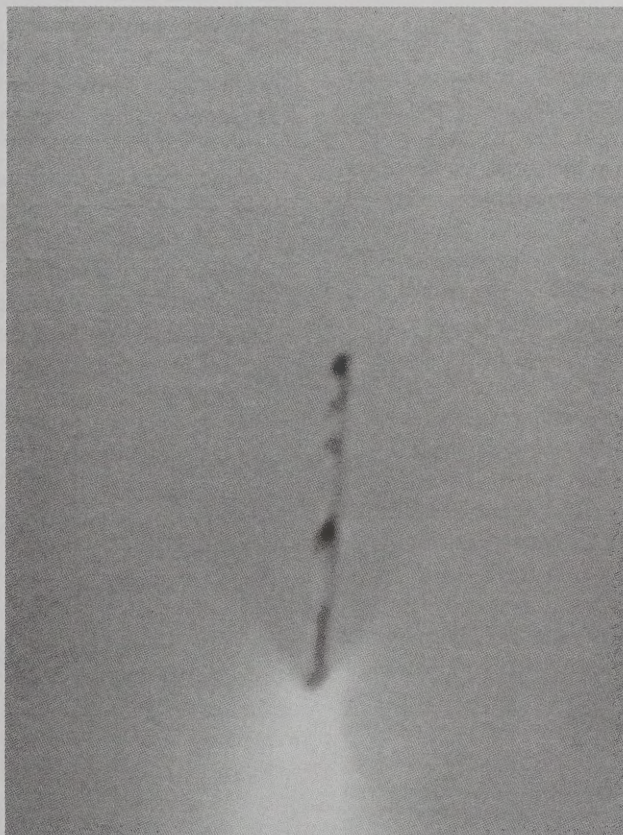
and began the paperwork to clear customs and specific Aeroflot checkout procedures. An Aeroflot flight arrives from and departs to Moscow every Wednesday making it always a big day at the Aeroflot desk in Mexico City International Airport. The Aeroflot staff were very kind and helpful to the extent that we were finished many hours before boarding. Aeroflot checked all our equipment to fly in the cabin of an Ilushin 63M. The IL6M has a hallway aft of the tourist class for carrying boxes and hanging winter coats and larger hand bags that don't fit in the overhead storage or under the seats. So, under our supervision, all of our equipment was safely stowed in the cabin by Aeroflot personnel. This was a great comfort for all of us as we did not want the satellite to have the kind of uncontrolled shock test that is routinely encountered by regularly stowed luggage.

We boarded at 1330 local time and departed one-half hour later. The flight takes 16 hours with a one-hour "in transit" stop at Miami International Airport, and another hour stop in Shannon, Ireland. These two stops are welcomed because you can stretch your legs, drink some Irish coffee, and use a full size bathroom. The food and drinks on board were very good. While the food is typical airline food, it is tasty and always served by helpful and kind Russian Flight Attendants who speak very good Spanish, English, and of course Russian. The flight sequence begins with first passing the drink carts serving soft drinks, and good quality white or red Russian wine. Then the food carts go by and there are always two choices of meats. Finally another run is made with the cart serving a very good Russian tea. Aeroflot really feeds you well during the 16 hours you spend traveling.

Moscow, Russia

The UNAMSAT Launch Team arrived at Sheremetevo International Airport at about 1600 local. The jet parked next to a platform and the passengers walked to the airport building just 30 meters away. We stayed in the aircraft until all of the passengers left so we would not have any problems carrying our equipment into the building. From there we were requested to clear immigration. We carried our equipment to the customs area where we were asked to complete a money declaration form. On this form, you have to declare all money that you were carrying while in Russia. A Russian authority stamps this form and you keep it until departure. Upon departure another form must be completed and compared with this initial form.

At this stage of the journey we got some help from our friends at the Sternberg Astronomical Institute of the Moscow State University of M. V. Lomonosov (MGU). With their help we carried



A rare photo of the launch of UNAMSAT-1.

our equipment to two MGU buses. We then traveled the 50 kilometers to downtown Moscow, to an observatory that belongs to Sternberg. MGU provided some electronic and optical labs there, where we could perform some tests on our equipment and install the separation pyrotechnical device.

Moscow was white with about 10 to 20 cm of snow. It was rather cold, about -5C, which was terrible for us because we left Mexico City with 22C temperatures. But there was much to do and we didn't have time to feel cold. We were taken to MGU where they have a building with accommodations for visiting teachers and students. The rooms were very nice and the view was just incredible. The MGU is located on a hill that overlooks downtown Moscow. You can see several buildings with the classical Stalinist architecture of three towers, the central one always taller. We could also see the golden covers of St. Basil's Cathedral that is located on one of the sides of the Red Square.

After unpacking we left our accommodation's building and went into the main building where we searched for a cafeteria and little restaurants. In Russia, we found food very inexpensive and even when it was not necessarily tasty, it was of good quality. There were also small improvised stores in the corridors where you can buy newspapers, bread, salami, some vegetables, cigarettes, and souvenirs. MGU is probably one of the most international universities in the world as you saw students from almost every country including, China, The Philippines, Venezuela, Korea, Malaysia, Saudi Arabia, Canada, United States, Japan, etc.

The next morning after our arrival and following breakfast an MGU bus took us to the observatory. My students were glued to the windows of the bus watching the streets of Moscow. For many students, it was the first time they had seen snow. At the observatory, I was told that a party of five (Dr. Eugene Moskalenko from Sternberg, Eugene and Genadi of Progress Co., Jose Luis Garcia, and myself) would leave on the train for Plesetsk. Jose Luis, a student of mine, had worked for months to master loading and testing the integrity of the UNAMSAT software. Meanwhile, a technician from Progress came to the observatory to install the pyrotechnical device without the explosive. Afterwards, we packed the satellite, tools, and power supply required for the integration to the rocket. While packing, Dr. Moskalenko asked us to remove all the UNAMSAT and MEXICO signs from our equipment boxes because of some concerns with military personnel in Plesetsk. While at the moment we could not understand this strange request, it would later become apparent to all of us.

From Moscow to Plesetsk

We left MGU for the train station in the afternoon. We departed for Plesetsk at 1630 local time travelling north on a 1,200 km train line that ends in the port city of Archangelsk located on the White Sea. We were headed for Plesetsk, which is approximately 350 km south of Archangelsk. It was a full moon night and the fields and forests were covered with snow. We spent a long time watching the scenery through the window with the light of the compartment turned off. There was no restaurant on the train but our friends were prepared and they shared with us some sliced bread, salami, and four bottles of Russian beer. We also had a couple of vodka drinks from them. The train made many brief stops varying in duration from 5 to 15 minutes. We passed by some industrial areas, crossed

over the Volga river, and most of the time there were views of fields and forests. Eighteen hours later we arrived at Plesetsk, where the marker on the side of the rail showed 859 km from Moscow.

We arrived at Plesetsk at 1400 local time and were greeted by military personnel who helped us move our equipment boxes into a bus. We traveled for 30 minutes to the military base and a town by the name of Miirny (population 40,000). Most of Miirny's residents work in the military factories and space facilities located in the area.

Plesetsk and Miirny, Russia

One of the six story buildings at the edge of the town has been converted into a hotel where the Israeli Techsat-1 Team and other visitors were accommodated. Upon our arrival, we were briefed by Vasily, head of the visitors guards, on the rules that would apply during our visit. Naturally, we could not use our cameras unless explicit permission was granted. Due to policy our Russian company from Sternberg was not allowed to stay in this hotel and was accommodated in another building at the back of the hotel.

Something very interesting happened just a few hours after our arrival. I took out my laptop computer and started working with a state vector that Moskalenko provided me before departure in Moscow. The door of our room was half open and one of the guards, Nicolai came to take us to dinner. He could only see half of the laptop and we told him we would be ready in a few minutes, so he left to wait for us at the door of the hotel. A few moments later Moskalenko came into the room asking if we had some communication equipment, namely Inmarsat. I told him no and then realized that Nicolai had seen part of the laptop computer. I asked Moskalenko to invite Vasily to inspect the laptop to verify that it was not a communication rig. When Vasily came, he walked several times around the table looking at the laptop. Meanwhile, in very bad Russian, I was explaining that it was only a small computer. Then to show him how we could predict satellite passes, I ran prediction software which drew a map. Vasily then said to Moskalenko that this proved that this machine was getting information from an overhead satellite. It took some more explaining until I ran a solitaire game in Windows, which made Vasily realize that this was a laptop computer.

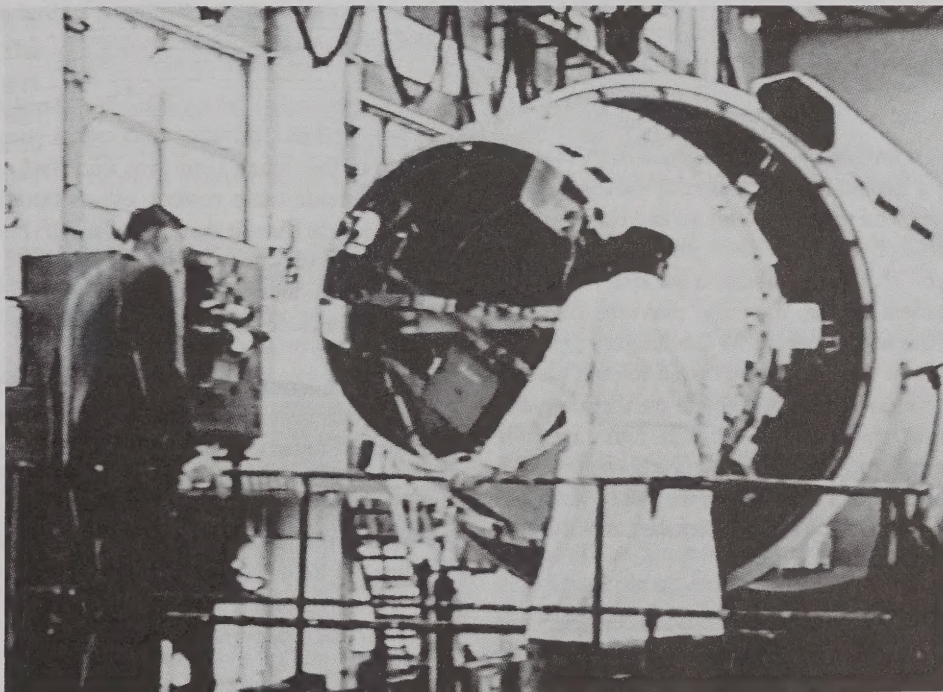
We then went to the dining room. We had to walk outside in the cold for about 100 meters to a one story building that had a large room, wooden walls, and tables placed to form a square. One side of the tables was assigned to the Israeli Technion Team (who were there to launch Techsat-1), American and Swedish visitors, and our party. The fourth side of the table was left unassigned. In the dining room, conversations immediately started as we introduced each other. I started asking questions of the Israelis about the integration building and their operations. They complained about communications to the outside world and how they were not allowed to use their Inmarsat laptop system. Then all became clear to me!

Integrating UNAMSAT-1

We were ready to go to bed when Moskalenko came by to say that we were scheduled for integrating to the rocket the next day. In addition, he asked that we should immediately load our software

and make the satellite ready. I objected, saying that we wanted to be in the clean room that had been assigned to us. However, he said that there was no time, that we should prepare UNAMSAT-1 in our room. After some discussion we decided to do this and we worked until 0300 local time when UNAMSAT-1 was ready, and we kept the charging power supply connected for the rest of the night. At 0800 we were taken for breakfast and afterwards carried all of the equipment boxes to a bus. We travelled about 25 minutes to the integration facility, a building with a tall roof and a traveling gantry with 50- and 10- ton hooks. Four very high metal towers were around the building and we were told that they were for lightening protection. Inside, the rocket was lying horizontal over jacks and at its side was a wheeled vehicle with round beds the diameter of the rocket. We carried UNAMSAT-1 in its box to a table that had been placed at the front of the rocket. We opened the box and were approached by a crew of Russian technicians wearing white robes, blue berets, and gloves.

The first operation the Russian technician performed on UNAMSAT-1 was to install the explosive in the pyrotechnical device. We were then asked for our approval for them to use the crane to lift UNAMSAT-1. They installed an attachment with four small hooks and raised the satellite in horizontal position and moved it closer to the rocket. It was amazing to see a 10.7 kg satellite hanging from a 10 ton hook! The technicians then went up the gantry where they invited Jose Luis and me to stand by their side to observe the installation of UNAMSAT-1 into the rocket. The position for UNAMSAT-1 was inside a conical canister with some small rectangular holes which allow you to view part of UNAMSAT-1 once it is installed. The connectors for the pyrotechnic and trickle



UNAMSAT integrated into rocket (0630 position)

charging were connected and a steel wire was passed through all the mounting nuts. After that, I was asked to remove the red covers, which Jose Luis and myself did very fast. The technicians started asking questions about the black and white paint on the antennae and the meteorite experiment. They were impressed by the precision of the launcher plate and the size and capability of the satellite. Then the Crew Chief removed his white gloves and gave them to me. I did the same and we all shook hands. They asked me to go down from the gantry and sign their operations ledger. I did so and immediately many different persons approached and shook hands with me. They told me that I was the first foreigner to sign

this book, marking a very historic moment for Russia and their intended opening to the world!

I asked for a copy of this page from the ledger but I was told that it was not possible, as no copying machines were available. So I asked to take a picture with my camera, but that was also not possible due to security reasons. We spent a few more hours in the building testing the umbilical connection to our charging device and placing the satellite for continuous charging under the supervision of Russian officer. Suddenly I was approached by one of the civilians in the building asking me to follow him with my camera. We came to the table where the ledger was, he opened the page where I had signed and told me to take a quick picture. I did so and I thanked him very much. We then returned to the hotel.

Cultural Exchange in Plesetsk

The following days were very dull as there was not much we could do. On one occasion a guard named Slava, asked if I would receive a visit from a local radio news reporter who wanted to record an interview. I accepted and a few moments later Elena, carrying a recorder, arrived at our room in the company of Slava and

Moskalenko. We sat down and she asked many questions in Russian. She also wanted me to answer in Russian. Using very bad Russian, I managed to reply to all of her questions while Moskalenko helped fill in words missing from my Russian vocabulary. When the interview finished we started an informal conversation. Elena lives in Miirny and she is married to a military commander. She works for Radio Moscow and her news program is transmitted from Archangelsk to an

audience within a 500 km radius. During our conversation, we touched folklore and Elena sang a few very nice Russian folk songs. Jose Luis and myself responded by singing a few Mexican songs and before leaving I mentioned to Elena the Russian songs I really enjoyed hearing.

That afternoon Slava delivered a guitar explaining that it was Elena's. Since Jose Luis plays guitar very well, we had a little practicing session of Mexican songs. That night after dinner we had a little gathering with Elena and some of the guards that by now were becoming close friends. A bottle of tequila was opened and

it was tried by all, even with the sacrifice that there was no lime and salt. We all sang songs and had a good time, feeling very nostalgic.

We only visited the integration building a couple of times. We also visited the integration room assigned to the Israeli Technion team where we saw their Techsat-1 for the first time. It looked like very fine work. The solar panels were covered with a crystal clear plastic that was to be removed as the last operation after installing it in the rocket. All of the Technion team were easy to work with and they were very friendly to us. During meals you could hear Russian, Hebrew, English and Spanish. However, everybody understood each other. The human language is the same; even more so when it is technical!

With little work to do and many days before launch, our guards became very conscious about our not being able to move around. They tried to be very helpful and offered to take us for a walk on Lenin Avenue, the main street of Miirny. One day a guard named Nicolai came by to say that he would make the arrangements if we would like to go cross-country skiing. We immediately accepted and later learned that he asked neighbors to lend us their skis and skiboots. We left the hotel and headed over a plain covered with snow that went down to a very flat surface. Nicolai explained to us that it was a frozen lake. We crossed over the lake into a forest and found a trail. There we put the skis on and got our first lesson in cross-country skiing. It was fantastic and we were allowed to take video cameras with us.

Another day, I made a comment to a guard named Eugene about the possibility of taking a Russian bath. Next day he told us that Nicolai, Eugene, Jose Luis, and myself would go to a Russian bath that afternoon. We completely undressed and jumped into a small pool with very cold water. Then we went into a wooden room with three benches, each stacked higher than the previous one. A thermometer hanging in the wall showing 94°C with very dry heat. After spending some time in this room you began to start feeling that you were going to ignite. At this point you leave the room and jump into the pool. After repeating this process four times we resigned ourselves to doing it again. We covered ourselves with towels and went into a room with a table where we had cookies and very delicious Armenian cognac. We sang Mexican and Russian songs and had a very good time.

Another day we were invited to visit a museum, school, and view monuments in Miirny. An official photographer came along and took photographs.

On Friday, March 24th, we were invited to bring our cameras to the integration facility to observe Techsat-1 integration to the rocket. When we arrived the integration facility was crowded with many military personnel and civilians that also came to view the final integration operation. Several Russian generals and other high-ranking officers were in attendance and we could see Elena with her tape recorder interviewing them. We also saw Guinadi Yasinsky who is the Deputy General Designer, Konstantin Beleayev, Chief of the Technical team, and others. I videotaped the integration of Techsat-1. I could still see UNAMSAT-1 through the small side opening of the canister, which by now was closed with a mechanical model of the Russian satellite that was closing the front of the canister. The front of this mock-up had a 60 cm tower holding a cylinder that was covered with a flat piece of metal

with holes that was serving as a base for the support of the separation assembly for Techsat-1. After observing the successful integration of Techsat-1, we left the integration facility and returned to the hotel.

That weekend went by very slowly. We had a gathering in the room of Anatoly, a member of the Israeli team. A few bottles of a very tasty Russian champagne were consumed and many Israeli, Russian and Mexican songs were sung by all of us, and of course were recorded by Elena who was also present.

Launch Day

On Monday, March 27th, we were informed that the rocket was on its way to the launch pad. Three stops were made on the way to the pad. One of these stops was used to recharge UNAMSAT-1 from a van that carried a very large generator, to which our charging device was connected.

The sky had been covered all previous days. We had hopes that it would clear for the launch, and Monday morning the sky was already broken. The clouds were moving fast from east to west which made me know that there was a high pressure zone to the east of us. So the chances of having a clear sky for the launch were improving!

We visited an arts and crafts school in Miirny. The teachers had prepared an exhibition and we all bought paintings and crafts. Tzvi from the Israeli team was very fast and bought almost all of the hand-made table covers, others bought paintings, and I was offered a little flute in the form of a calf. I was told that the northern Russians are very superstitious and that if I would make a wish and play the flute, the wish would be granted. So everybody asked me to play for a clear sky and I did.

On the morning of Tuesday, March 28th, the day of the launch, the sky was completely clear. We went to breakfast and then boarded the usual bus and took a 30 minute trip to the local airport. We waited there for the arrival of two airplanes that flew in with guests invited to view the launch. Four of my students arrived from Moscow in one of the planes. Then we traveled in a caravan of buses for about 2 hours to the launch pad. We could see some clouds forming at a medium altitude and we were hoping that they would not cover the rocket path.

When we arrived we saw a building with the roof opened to the sides where the rocket was mounted on its transport rig and still lying horizontally. We videotaped all the details and then were asked to go back to the buses to be taken to a site about 4 km from the launch pad where we could see the launch. When we arrived we saw cameras from CNN, UPI, Itar-Tass and several Israeli TV channels. We took positions to have a clear view of the rocket in hopes of using the several cameras we were carrying. By now the cloud cover was 80 % of the sky and the chances to see the rocket for more than a few seconds were very slim.

At 1300 local (0900 UTC) we saw the rocket swinging fast into vertical position and in two seconds it was launched by an explosive on the container. At about an altitude of 50 meters the rocket ignited and started a very fast climb. The noise was very strong and you could feel your body vibrating on a low frequency due to the noise.

On a local PA system we could hear in Russian the phases of the flight. The altitude, the velocity and staging of the rocket were announced.

All went well until the fourth stage. The separation of the third stage was not announced and the PA system went silent. We only saw the rocket leaving its carrier tube and flying into the cloud. There was an opening in the clouds and we saw the smoke trail of the rocket again, flying away and performing the first stage separation. The rocket then again went into the clouds.

We traveled on the buses back to the launch pad and found the tube from which the rocket was launched in vertical position, smoking. The surrounding area was muddy and wet, as firemen had used a lot of water to quench the fire produced by the initial explosive.

The Israelis started handing out some envelopes that contained a souvenir leaf released by the Israeli Postal Authority. I requested signatures on the envelope of all the Israeli team as well as from the Russian technical team. We were requested to go back to the buses and when we were ready to leave, a press conference was announced. I stepped down to smoke when I saw General Yuri Yashin approaching an area where some of the TV channels had set their cameras. I approached the place and was standing very close to the General who decided to speak in Russian. Victor Andriushin from Complex Co., the deputy director of the launching company, was translating into English. The General was almost smiling and in short phrases he explained that the launch had taken place on Tuesday because the Israelis would not accept a Saturday launch. Sunday and Monday were very difficult days for the Russians to launch. He also said that this launch was a demonstration of their hope to launch satellites for many other countries in a program that contemplated very wide international cooperation. Then he explained that there had been some telemetry problems and how he had ordered an aircraft to depart to one of the ground stations in order to obtain a telemetry tape. This telemetry would then be analyzed and they would give us information about the result of the launch by 1600 local.

We then boarded the buses and traveled back to the airport where about half of the guests departed for Moscow. My students were in a very gloomy mood as they left and I told them that I would try to call them on the phone. I also asked them to keep a watch on the UNAMSAT-1 and Techsat-1 frequencies as they had installed a ground station in MGU. We donated (to one of the radio clubs) a transceiver and an azimuth-elevation rotator. They built the antennae and obtained a computer.

Post Launch and the Future

I returned to the hotel to start packing and to try and telephone Moscow. After trying several times, I managed to contact Dr. Bisiacchi, Director of PUIDE which is the space program at

UNAM. He had been monitoring the frequencies of the two satellites with no luck. We were then sure that something really bad had happened. Meanwhile, my Russian friends and guards told me that I was expected at the Orbit Restaurant where a banquet was being served. We walked to the restaurant which is located only a few blocks away from the hotel. General Yashin was presiding and the attendants were quiet. Shlomo, 4X1AS, introduced me to the Israeli Ambassador in Russia, who was a woman with a very nice personality and a friendly smile. There were many toasts including one that I was asked to make by General Yatsin. It was one of the most difficult moments in



Technion Team members from Israel integrating Techsat-1 to launch vehicle

my life. I had to do a toast knowing that something went very wrong and knowing that he knew but was not saying. I decided to mention the high quality of the technical staff we had met in the Plesetsk Polygon and how I hoped we could extend our relationship in future projects. I then sat with Jim Stuart and George Chadwick, my American friends, who on behalf of Teledesic attended the launch. They were very kind and I was thinking that you got to know your friends when times are sad. I will never forget all the words they spoke to me at that moment.

I left the banquet and went back to the hotel with Jose Luis to finish packing my belongings. As we were packing, one by one our guards showed up with presents. Some of them cried quietly and only had good words to us. Everybody was very sad and tried to ease our feelings.

At 2300 local we boarded the train to Moscow and traveled for 18 hours without any news. It was a very long trip; to us, it felt infinitely long. Jose Luis didn't sleep and did not eat. I couldn't sleep and was just thinking of how to reduce the impact of all this on my students. I knew that UNAM will give us all the required support to continue but my worry was with the human side of the project.

We arrived in Moscow and carried the equipment boxes and luggage to a taxi and went to the University. We went to the shack on the 29th floor of the right tower and found the students sitting on the floor and very sad. They had not heard any signal. They had received a phone call explaining that there had been a failure in the fourth stage and the rocket had not reached orbit and that it may

have gone down in the Sea of Okotsk, south of the Kamchatka peninsula.

I asked the students to gather and we held a meeting to set new targets for the program. We all decided that we would work very hard in getting the ground-based model (UNAMSAT-B) into flying condition. If possible, I was going to find a new launch this same year. The mood changed and all the students started making plans to see what could be improved and what had to be done to get UNAMSAT-B in the best possible shape in the least amount of time.

I immediately made some appointments with several cosmic (space) industries in attempts to locate a launch. I visited some industries and a couple of museums. One of them, the Moscow Aviation Institute (MAI) is very impressive with 27,000 students. In addition, three years ago MAI started accepting foreign students and presently there are 60 American students. MAI has many connections with the space industry of Russia and almost all industry directors are MAI graduates. MAI has 12 colleges including:

- Propulsion College, which has working engines and turbines;
- Rocket College, with incredible labs for the students;
- Helicopter College, that also has helicopters for the students to work on.

MAI has all kinds of aircraft, allowing students to inspect and discuss all the construction details with their teachers. Other MAI facilities include a supersonic and two sub-sonic wind tunnels. In January 1995, Dr. Alexander M. Matveenko, MAI Rector, visited UNAM in Mexico City where we signed an academic exchange agreement that allowed us to send students and receive professors from MAI.

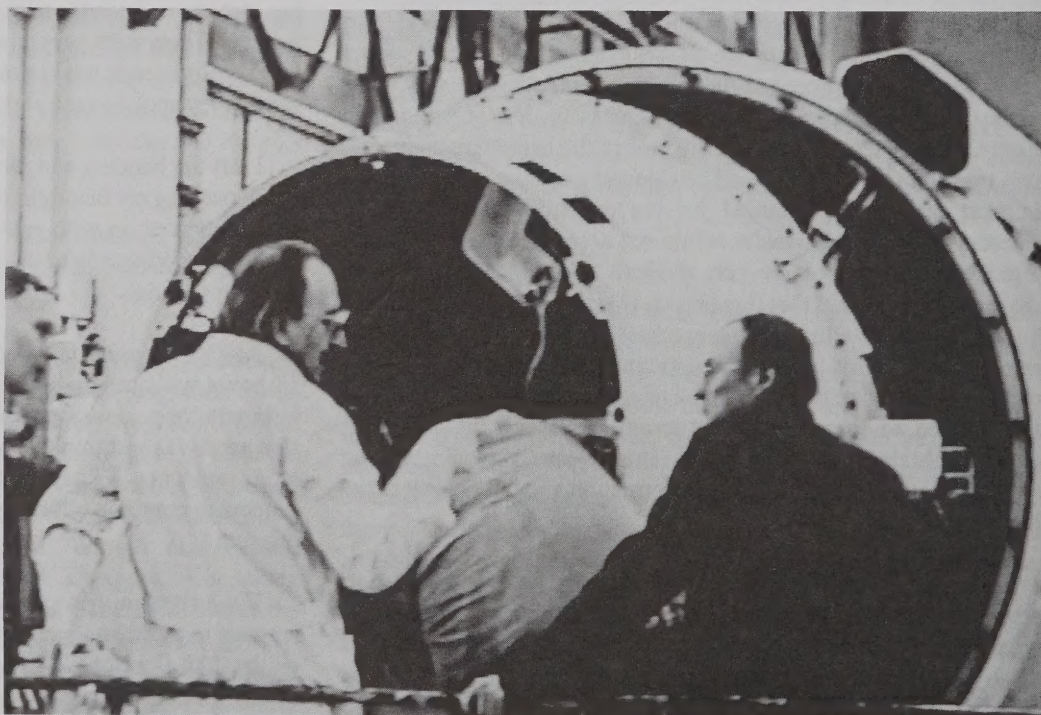
We also visited Lavotchkin Association, one of the most prominent satellite building companies in Russia. Lavotchkin Association are builders of all the Luna satellites (including the Lunachod), Venera, and the Mars series satellites. The Mars satellite has not been very successful; they claim they can manage the female planets (Moon and Venus), while they are not so lucky with male planets (Mars). While visiting Lavotchkin Association, I was allowed to handle Luna-16 which went to the moon and returned with lunar soil samples to Earth. Of the three Luna satellites which returned to Earth, two are at Lavotchkin and the third is on permanent world tour.

On Friday evening, March 31, we had a meeting at the Sternberg Astronomical Institute. Dr. Cherepaschuk, Institute Director

was presiding and he regretted what had happened during the launch and offered to help us in any future venture. We signed a protocol releasing each other from all responsibilities and monetary demands. Suddenly the word was passed to Dr. Michael Belayev, who works in Progress, another of the very fine cosmic companies in Russia. We had visited their building two years ago, including the control center for MIR Space Station. Very solemnly he announced that a Directors Meeting of the Cosmonautic Federation considered all the work done in our common project named RUMEX, and decided to co-decorate Dr. Guianfranco Bisiacchi and myself with their highest award, the Yuri Gagarin Gold Medal. That was an honor I was not expecting. It took us both by surprise and my eyes went wet. I could see Franco, as I called him, also was very moved and with his eyes also wet. Dr. Belayev pinned the medals on to our lapels and we embraced. It was a very touching moment. Dr. Belayev explained to me that the meeting had taken place about a month before the launch and when they learned about the fatal result of the launch there had been some consulting because they wanted to avoid that the medal be taken as a consolation prize. Finally they decided that regardless of the result of the launch, the work we had done together was the real reason for them granting us these medals.

From Hydrazine to Humanity

We returned to Mexico City on Wednesday, April 5th, where the press greeted us at the airport. The main question was "What now?" Of course the answer that I provided was we will try to put UNAMSAT-B in orbit this year. This response was without me knowing that the Science Coordinator of UNAM had made similar declarations to the press a few days earlier, saying that UNAM will give us all the required support.



Final preparations are made on the Start launch vehicle

Two days later and suffering a tremendous jet lag I came to my lab and started checking my mailbox. I found about 800 messages of condolence and moral support from all parts of the world which I intended to answer one by one. I also found, as we say in Mexico, *the hair in the soup*. Someone was denying the origin and nationality of UNAMSAT as if it was a secret who and where it was made. It is too bad that people like this exist, but on the other hand life would be boring without stupidity. Black is black because there is white.

My lab at UNAM is back to work at full speed and I am trying to find a launch for UNAMSAT-B. Tom Clark is coming to visit us in a few days. I guess that he wants to repeat his reaction after dark Friday. But it will be very good for me to prove to Tom that we had learned that lesson and we are back on our feet and working very hard to make our dream a reality!

There is a very deep feeling of gratitude to all of you who sent us words of hope and support. Some rockets are fueled by hydrazine. Ours is fueled by friendship and maturity, derived from the fact that we can live in peace with the things we can no longer change. But we can work as hard as needed to do the things we want or need to do. ■

AMSAT Journal Telemetry

Some Corrections

A reference was omitted from the article "Re-Entry of Oscar - 13" printed in the May/June issue of *The AMSAT Journal*. A listing of the re-entry calculation program discussed is available via FTP from [ftp.amsat.org](ftp://ftp.amsat.org/amsat/articles/g3ruh/a114.zip) as file [/amsat/articles/g3ruh/a114.zip](ftp://ftp.amsat.org/amsat/articles/g3ruh/a114.zip).

Two errors, appearing in the biographical statements which accompanied the ballots for AMSAT Board of Directors, have been called to our attention.

a. In the biography submitted by Bob Meyers, W1XT; the period of his employment at ARRL Headquarters was stated as 1968 to 1970. It was 1968 to 1979, which is twelve years instead of the reported 2 years.

b. In the biography submitted by Bill Tynan, W3XO; the sentence reading "One vehicle for this has been the Apogee View Column which *HAS* appeared in every issue of *The AMSAT Journal* since I became President." appeared "One vehicle for this has been the Apogee View Column which *AS* appeared in every issue of *The AMSAT Journal* since I became President."

Both of these errors were completely inadvertent and AMSAT regrets any problems they might have caused. All members are encouraged to review the statements submitted by the candidates and return their marked up ballots in time to arrive at AMSAT Headquarters by September 15.

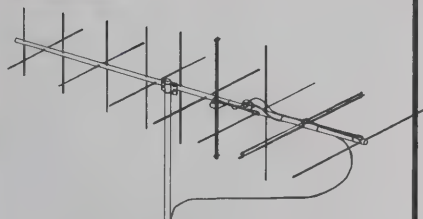
Meeting of Amateur Radio Satellite Enthusiasts in the Greater Washington, DC Area

An AMSAT meeting for members in the Washington, DC area is scheduled for 1:00 pm, Sunday, September 24, 1995 at the NASA/Goddard Space Flight Center Visitor Center Auditorium in Greenbelt, Maryland [telephone: 301-286-8981 and talk-in via WA3NAN/R 146.835 (-) MHz FM]. While advance registration is not required there will be a \$3 general admission fee. Presentations and informal "show 'n' tell" demonstrations relating to amateur radio and the amateur space program will be given throughout the meeting. There will also be a "walking tour" of the NASCOM (NASA Communications) facilities at 11:00 am and a model rocket launch demonstration by a local youth group at 1:00 pm. In addition there will be a social period where you can renew old acquaintances and make new friends. Those interested in making a presentation or obtaining further information on the meeting should contact Pat Kilroy, WD8LAQ at 301-249-3396 (home), 301-286-5910 (work), or wd8laq@amsat.org.

Satellite Operation from Easter Island

Max Bachi, XE1XA, reports that a multipurpose expedition is planned for Easter Island and Salas y Gomez during September and October 1995. From the La Perouse Campground on Easter Island (grid square DG52iw) the group will be will conduct a DXpedition from September 2-15, 1995. Satellite operations will be include in the DXpedition using the callsign of XR0Y. The main objective of satellite operations will be the opportunity to provide a new country to work via satellite, promote interest in satellite operation, and demonstrate satellite operations using portable equipment. Further information can be obtained by contacting Max Bachi 525-291-6916 (home telephone) or 525-394-8120 (fax).

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AMSAT at Texas Ham-Com '95

AMSAT members were very active at the 1995 Texas State ARRL Convention held June 9-11, 1995 in Arlington, Texas. Over 7,500 participants attended the three day convention that was held next door to the Texas Rangers' new baseball stadium between Dallas and Fort Worth. The AMSAT booth was well represented by members who answered participants' questions and provided them with the latest AMSAT materials. Throughout the convention, various presentations on AMSAT activities were made, including:

- How to participate in a school SAREX project
- Tips on working the Space Shuttle and Mir
- Overview and update on Phase 3D
- Beginner's tips on working satellites

Now's the time to make plans for next year's event as promoters are promising a bigger and better Texas Ham-Com '96.



Jimmie Haygood (left), and AMSAT members Donna, N5WOE (center), and Randy McKinney, N5SVW (right) briefed participants on their planning efforts for STS-71 SAREX activities. On July 4, 1995, Pilot Charlie Precourt, KB5YSQ and Mission Specialist Ellen Barker, KB5SIX contacted students from Ms. Haygood's fifth grade class at Benbrook Elementary School, Texas making for a memorable Independence Day. STS-71 SAREX also communicated with three other schools in the United States and one school in Russia. (KC5JVB photo)



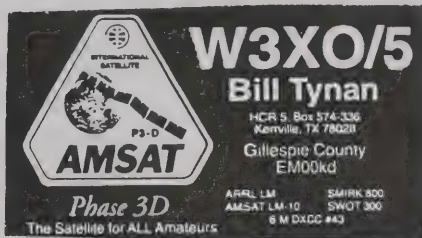
AMSAT Vice President, User Services, Andy MacAllister, WA5ZIB, provided participants with an array of tips on how to successfully monitor and work SAREX missions. Also included with his presentation was an interesting five minute video of a Mission Specialist making a QSO on-board the shuttle. (KC5JVB photo)



One of the several presentations that AMSAT Executive Vice President Keith Baker gave participants on the latest news on Phase 3D developments. Included with Keith's presentation were some first publicly-seen photographs of Phase 3D's Specific Bearing Structure. (KC5JVB photo)

Phase 3D QSLs

Show your support for Phase 3D every time you QSL!



Front

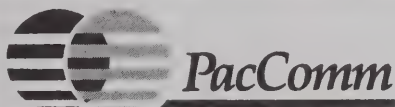
This confirms a QSO with _____
 on _____ at _____ Z
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 Your _____ signals were _____
 Rig _____ W to _____
 Ant. _____
 Thanks for the contact and 73.

Back

Cards are postcard size with red background and gold lettering for name & call. Other lettering in white. Insert is light blue with dark blue lettering & AMSAT logo is red. Spacecraft is gold with purple solar panels. Earth is various shades of blue & white.

Please print your name & call as you want them to appear on the right front of your QSLs.

Name _____ Call _____ Address _____
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 1,000 cards \$150, Note: Orders will be processed in batches of eight.
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 Daytime Phone: (____) _____ Signature _____



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FASat-ALFA, THE FIRST CHILEAN SATELLITE

by **Fernando F. Mujica**
Lt. Col., Aeronautical Engineer
MSc. Nuclear Engineering (M.I.T.)
FASat-Alfa Project Manager
Space Division, Chilean Air Force
email: f.mujica@surrey.ac.uk

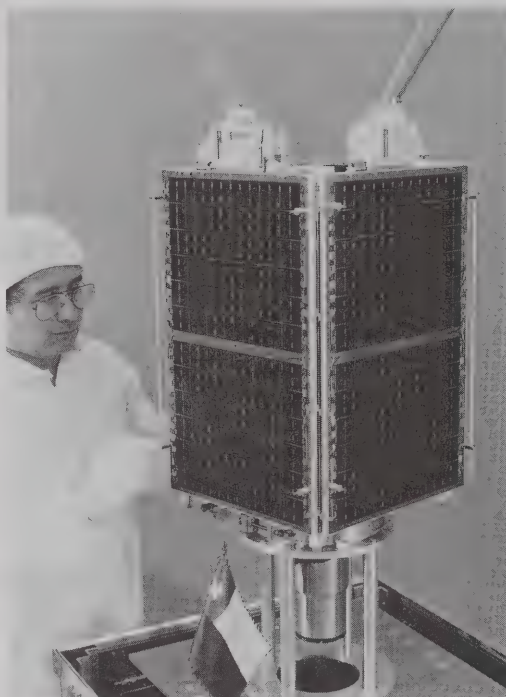
Editor's Note: FASat-Alfa is scheduled for launch in August 1995. Watch for frequencies and Keplerian elements to be announced after launch via AMSAT News Service bulletins or AMSAT-BB.

Introduction

FASat-Alfa will be the first Chilean satellite, and is being constructed under a Technology Transfer Program between the Chilean Air Force (FACH) and Surrey Satellite Technology Ltd (SSTL) of the United Kingdom. The primary goal of the Program is to obtain for Chile the scientific and technological experience required to develop a National space capability. The FASat-Alfa mission will create a group of engineers with aerospace experience who will operate the first Chilean satellite in orbit from the Mission Control Station (ECM-Santiago) in Chile.

FASat-Alfa Satellite

The FASat-Alfa satellite of 50 kg. will use the modular UoSAT bus, proven in ten previous missions. The satellite is being constructed at SSTL by a combined group of engineers from FACH and SSTL. FASat-Alfa will be launched in late August 1995



The Chilean FASat-Alfa Project Manager, LTC Fernando Mujica, performs final adjustments to the FASat-Alfa before its flight to Plesetsk in Russia for launch in late August. The launch will be on-board a Ukrainian Tysklon as a secondary payload of the first Ukrainian satellite, Sich-1.

as a secondary payload into a circular orbit of 650 kilometers at 82.5 degrees inclination, on-board a Tsyklon rocket made by KB Yuzhnoye of Ukraine from the Plesetsk Cosmodrome in Russia. The main payload of that launch will be the Sich-1 spacecraft which will be the first Ukrainian satellite.

FASat-Alfa Bus Systems

The FASat-Alfa is based on a bus that is integrated in a 600mm by 350mm by 350mm box. The box is formed by 11 modules of heights between 26 and 50 mm. On top of these module boxes there is a structure called the Earth Observation Platform which encloses all the cameras and special sensors that need to point to the Earth. A breakdown of the FASat-Alfa satellite is provided as Figure 1.

The FASat-Alfa bus systems include a number of enhancements over previous SSTL missions. The main enhancements include the new local area network CAN, and a new On Board Computer (OBC) based on a Intel 386EX processor.

Experimental Payloads

The experimental payloads on board FASat-Alfa will be the following:

- Ozone Layer Monitoring Experiment (OLME)
- Data Transfer Experiment (DTE)
- Earth Imaging System (EIS)
- Global Positioning System Experiment (GPS)
- Solid State Data Recorder Experiment (SSDRE)
- Educational Experiment (EdEx)

OLME Experiment

This experiment is very important for Chile because of the geographic location of the country within the depletion area of the Ozone Layer in the Antarctic. This experiment is based on the measurement of the ultraviolet solar backscattered radiation in frequency bands around 300 nanometers. The experiment will have two types of devices in order to measure that radiation: Ultraviolet cameras, based on special CCDs, and Ultraviolet photodiodes.

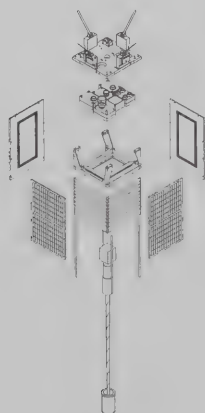


Figure 1: FASat Alfa Breakdown

Measurements will be made in the Antarctic and sub-Antarctic regions of Chile, and the data collected with this experiment will be correlated with the ground based observations of the Ultraviolet Radiometric Network run by the Meteorological Directorate in Chile.

DTE Experiment

The objective of the Data Transfer Experiment is to provide the Space Segment Infrastructure, i.e. necessary hardware, satellite interfaces, firmware and software, to allow a variety of data communications experiments and demonstration objectives to be supported. The potential experiments can be grouped into four major activities:

- Uplink experiments-data collection
- Duplex/Two-way experiments-data transfer (collection and distribution)
- Downlink experiments-data distribution
- Technology demonstration-enhanced modulation/data rates/small terminals

The hardware for the DTE consists of two redundant receivers and a redundant Digital Signal Processing (DSP) unit based on C31 processors. The FASat-Alfa uplink is in VHF and the downlink is UHF, both in the WARC92 "Little LEO" frequency bands, and will use a digital store and forward transponder. Even though FASat-Alfa is not an amateur satellite, the operation will be similar to UoSAT-5 and Kitsat 1 and 2.

EIS Experiment

The Earth Imaging System on FASat-Alfa will have two visible-light cameras: a wide angle camera with a ground resolution of 1500 meters, and a narrow angle camera with a resolution of about 150 meters. The wide angle camera will have the same field of view as the Ozone monitoring cameras. These cameras will be located in the Earth Observation Platform. They provide snapshot images of the Earth, are then stored on board the satellite for downloading at a later time.

GPS System

The function of the GPS receiver is to determine the position of the satellite in space and use this for on-board generation of Keplerian elements, using the 32 bit transputer system.

Solid State Data Recorder Experiment

This system will provide 2 Gigabits (256 Megabytes) of solid state storage memory based on new RAM technology. Each system of FASat-Alfa will have access to this memory through the CAN local area network. Main users will be the OLME and EIS payloads; the SSDRE will store more than 600 images of 300 kilobytes each. This experiment is in collaboration with Sanders, a Lockheed

Martin company from the United States.

Educational Experiment

This experiment is directed to Chilean youth, the idea being to generate a special mood about space with a satellite that they could feel more close to themselves. The EdEx will use the DTE experiment through digital processing in the DSP unit, in order to generate a telemetry signal that can be received by low cost receivers and a personal computer. DSP will also produce digitized voice that can be received in simple receivers.

The experiment will be run during the Chilean academic year (April to November), transmitting one or two times a month. In this way the EdEx will not interfere with the other payloads. The benefit for the curricula of the students is that they will have to develop at least the following areas of knowledge related to space:

- Tracking of satellites
- Communications
- Telemetry analysis of electric and thermodynamic parameters

Mission Control Station, ECM-Santiago

The ECM-Santiago station is a complete command and control groundstation from the SSTL product line of groundstation systems. Using this system, ground controllers can command the spacecraft both via the direct command link and via the on-board computer, collect and archive telemetry data, interact with the store-and-forward communications system, collect and archive spacecraft housekeeping data as well as data generated from the various experiments resident on the FASat-Alfa spacecraft platform. This will be the only station in Chile capable of controlling satellites, and will be located in a building at Los Cerrillos Air Base in Santiago. Installation was completed in February 1995. The FASat-Alfa commissioning will be undertaken from ECM-Santiago by Chilean and SSTL engineers.



Working around the FASat-Alfa flight model is Victor van der Zel, SSTL Project Manager (left) and LTC Fernando Mujica, Chilean Project Manager (right).

Your Callsign or Name Can Fly on Phase 3D

Ron Broadbent, G3AAJ, informs us that AMSAT-UK is sponsoring a program that will allow donors to have their name or callsign engraved onto an aluminum plate and placed on Phase 3D prior to flight. After launch, donors will also be provided a photograph of the plate installed on Phase 3D and an engraved certificate or plaque. The names/callsigns will also be listed in an upcoming issue of *The AMSAT Journal*. This arrangement has been agreed to by the Phase 3D Project Team and is available as of this date.

This offer is open to any individual sending at least \$250 (approximately £150) or business, universities or government agencies sending \$8,000 (approximately £5,000). Clubs are also welcomed to have their callsign placed on the Phase 3D plaque and are asked to contribute an amount (\$250 minimum) that reflects the size of their membership. All methods of payment including currency, Mastercard, Access, and VISA are accepted and will be acknowledged with a receipt. Ron asks that you **give it a shot and make him work** by sending your donation to:

Ron Broadbent, MBE, G3AAJ
94 Herongate Road, Wanstead Park
London, E12 5EQ, England
Telephone: 44-0181-989-6741
Facsimile: 44-0181-989-3430
Email: r.broadbent@ee.surrey.ac.uk

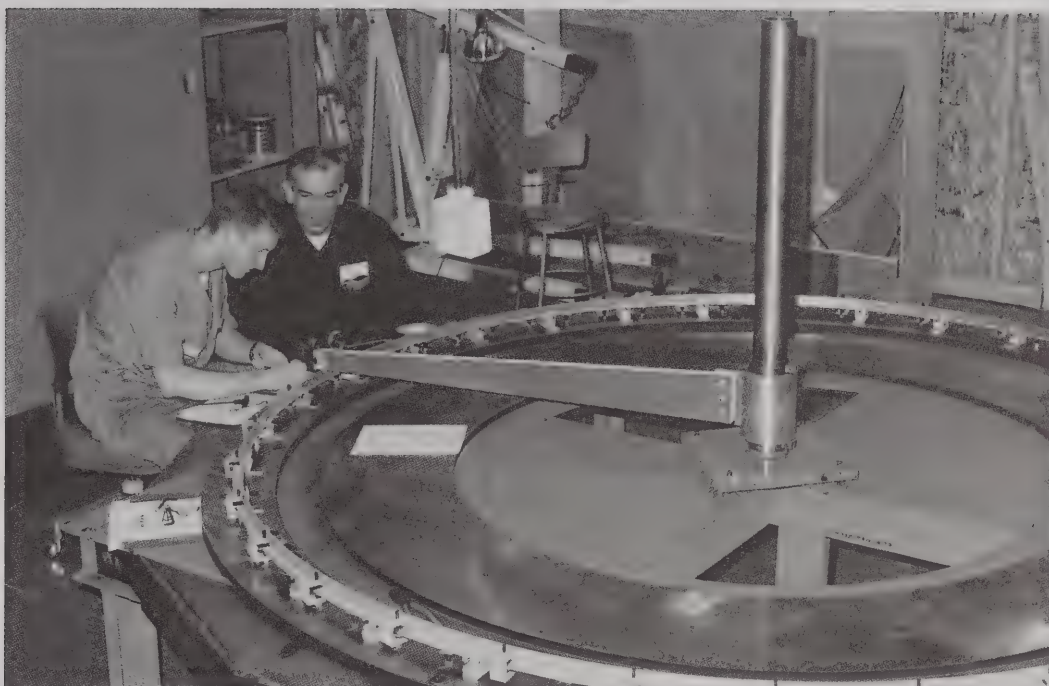
Ron reminds us that there are now only **five months** before the start of the Phase 3D launch campaign, i.e., tying the blue ribbon, fitting the final module, and screwing the last bolt prior to carriage to the launch site. In addition to using funds to complete construction of Phase 3D, funds are also required for use during the life of Phase 3D for command stations around the world to control this spacecraft for the benefit of **ALL** radio amateurs. Such as the case with the present AO-13, command stations are normally funded to the greater or lesser extent by the AMSAT group of the respective country. This is a hidden charge on those groups which the majority of the world's amateurs rarely think about, let alone subscribe. So act today and fly your callsign or name on Phase 3D!



Jeff Zerr proudly displays his handiwork...the completed Phase 3D flight model L-band antenna. The antenna is based on a short-backfire design and uses an all-aluminum wedding cake baking pan for a reflector! (AMSAT-NA photo by Keith Baker, KB1SF)



Mike Garrity, N4OZC, displays a flight model prototype of Phase 3D's S-band antenna. (AMAT-NA photo by Keith Baker, KB1SF)



Student Project Leader Gene Hansen performs a precision alignment on the very first segment of Phase 3D's Specific Bearing Structure (SBS) in the Phase 3D Lab at Weber State University in Ogden, Utah. The SBS will be used to carry the Phase 3D satellite to orbit aboard the Ariane 5 rocket rescheduled for launch in late May 1996. (AMSAT-NA photo by Dick Jansson, WD4FAB)



The AMSAT booth at NAECON, The National Aerospace and Electronics Conference, held in Dayton, Ohio, May 22 - 25. Left to right are Keith Baker, KB1SF, Bill Tynan, W3XO, Steve Grant, N8AJD, and Gerd Schrick, WB8IFM. AMSAT's participation resulted in many potentially valuable contacts being made.



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The KD2BD Pacsat Modem

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Do you have a desire to become active on Pacsats, but lack the "special modem" necessary for your TNC? This high-performance Pacsat modem will help get you on the air, and bring worldwide

space age digital communications to your doorstep! The KD2BD Pacsat Modem is a low cost, high-performance 1200 bps BPSK modem designed to interface between a packet radio TNC and an amateur satellite ground station and allows full-duplex access to the 1200 baud "Pacsat" constellation of amateur satellites.

Important features of this modem include:

- High immunity to noise and interference
- "Matched filter" demodulator performance

- Non-limiting (linear) balanced phase detection
- Wide range automatic gain control
- Doppler-correcting AFC for the downlink receiver
- Compatible with current and future Pacsats
- Uses readily available components
- Easily interfaces with standard TNCs
- Operates from a single +12V DC power supply
- Suitable for terrestrial communications
- Provides outstanding performance

Satellite Orbital Elements

By Ray Hoad, WA5QGD

Satellite	AO-10	AO-13	AO-27	RS-10/11	RS-12/13	RS-15	AO-16
Catalog Number	14129	19216	22825	18129	21089	23439	20439
Epoch Time	95178.43693645	95178.98399080	95177.70170491	95175.70726171	95176.14122222	95176.21862484	95176.24117049
Element Set	360	53	400	78	810	59	905
Inclination	26.4607	57.5320	98.6164	82.9251	82.9241	64.8190	98.5785
RA of Node	261.0892	179.3228	253.9800	53.5142	94.8852	242.0007	262.1611
Eccentricity	0.5998757	0.7302384	0.0007910	0.0013397	0.0029618	0.0167800	0.0011078
Arg of Perigee	288.5034	12.4583	190.9728	70.1404	147.4206	260.6927	171.7073
Mean Anomaly	17.8772	358.6397	169.1278	290.1189	212.8777	97.4988	188.4294
Mean Motion	2.05880941	2.09724829	14.27665704	13.72353643	13.74058635	11.27524017	14.29944099
Decay Rate	.00000139	-.00000271	-.00000005	.00000037	.00000049	-.00000039	.00000005
Epoch Rev	9051	5388	9112	40100	21986	2042	28291
Satellite	DO-17	FO-20	IO-26	KO-23	KO-25	LO-19	UO-11
Catalog Number	20440	20480	22826	22077	22828	20442	14781
Epoch Time	95176.22886700	95175.26990383	95177.23443690	95176.52153178	95177.22886794	95175.25406913	95178.53668414
Element Set	905	801	399	502	377	905	808
Inclination	98.5802	99.0721	98.6175	66.0791	98.6132	98.5816	97.7826
RA of Node	262.6151	262.5558	253.6178	218.3142	253.6484	261.9900	180.5883
Eccentricity	0.0011077	0.0539961	0.0008418	0.0006861	0.0009879	0.0011784	0.0012154
Arg of Perigee	170.7818	217.1975	194.3468	196.9631	177.7271	174.3584	143.5728
Mean Anomaly	189.3569	139.0549	165.7464	163.1159	182.3953	185.7721	216.6306
Mean Motion	14.30085365	12.83230938	14.27773734	12.86291715	14.28103734	14.30159490	14.69355725
Decay Rate	.00000010	-.00000002	.00000018	-.00000037	.00000004	.00000042	.00000132
Epoch Rev	28293	25185	9106	13480	5916	28281	60542
Satellite	UO-14	UO-22	WO-18	MIR	HUBBLE	NOAA-9	P3D (Proposed)
Catalog Number	20437	21575	20441	16609	20580	15427	00001
Epoch Time	95175.22005865	95179.21859781	95175.72152835	95178.66157061	95177.53366769	95178.78596526	91080.00000000
Element Set	106	612	909	102	677	304	1
Inclination	98.5663	98.3935	98.5801	51.6485	28.4686	98.9994	63.4349
RA of Node	259.4766	250.2662	262.0878	105.2627	350.8410	237.5780	225.0000
Eccentricity	0.0010879	0.0006723	0.0011778	0.0004953	0.0006801	0.0013956	0.6774378
Arg of Perigee	173.7284	249.5770	172.8370	121.1692	41.0489	238.3099	270.0000
Mean Anomaly	186.4028	110.4692	187.2990	238.9758	319.0631	121.6710	0.0000
Mean Motion	14.29890151	14.36980771	14.30056433	15.56968809	14.90895633	14.13713945	1.50000000
Decay Rate	.00000003	.00000028	-.00000001	.00002044	.00000477	.00000040	.00000000

The KD2BD Pacsat Modem consists of a 1200 bit per second BPSK demodulator for receiving Pacsat transmissions, and a Bi-Phase Manchester encoder for generating Pacsat uplink signals. The demodulator uses coherent phase detection and correlation decoding techniques that are capable of demodulating BPSK signals well into the noise level. It also includes an Automatic Gain Control (AGC) system to compensate for signal strength variations, and an Automatic Frequency Control (AFC) for tuning the downlink receiver in response to Doppler shift during a satellite pass. The demodulator is very sensitive, and is capable of locking into BPSK signals so weak they are barely audible above the ambient receiver noise. The modulator produces low-distortion 1200 bit per second Bi-Phase Manchester code suitable for generating Manchester encoded FSK when used with a standard 2-meter FM voice transmitter, or BPSK when used with a SSB transmitter.

The KD2BD Pacsat Modem was originally designed to interface with an MFJ 1270B terminal node controller (TNC-2 clone), and a Yaesu FT-726R multi-mode VHF/UHF communications transceiver. Suitable interfacing modifications should allow proper modem operation with other TNCs and ground station radio equipment. The specifics for doing so are left to the expertise of the reader.

The Pacsats

Orbital Satellites Carrying Amateur Radio (OSCARs) have been a part of amateur radio for over 30 years. With the growing popularity of terrestrial packet radio communications on the amateur bands, recent OSCAR satellites have been designed to make use of the AX.25 protocol in their communications with ground stations. Some satellites, such as DOVE-OSCAR-17, use the protocol for the transmission of telemetry information through beacon transmitters, while others use the protocol to provide full duplex communication links with the satellites' transponders. Amateur satellites containing packet radio store-and-forward transponders are known as "Pacsats".

The current roster of satellites making 1200 bps NRZI, HDLC, AX.25 protocol compatible packet radio transmissions on amateur frequencies includes

PACSAT-OSCAR-16, DOVE-OSCAR-17, WEBERSAT-OSCAR-18, LUSAT-OSCAR-19, FUJI-OSCAR-20, and ITAMSAT-OSCAR-26.

Of these satellites, only DOVE-OSCAR-17 uses audio frequency shift keying (AFSK) modulation on a narrow-band FM carrier which is compatible with existing terrestrial VHF-FM and UHF-FM packet radio communications. The remaining satellites use Binary Phase Shift Keying (BPSK) modulation. As popular and as widespread as the AFSK-FM method of transmission is for 1200 baud packet radio communications, AFSK-FM and its popular demodulation methods yield a level of performance that leaves a lot to be desired. Steve Goode, K9NG, has shown through extensive testing that a Tucson Amateur Packet Radio (TAPR) TNC-1 internal Bell 202 modem required a signal level that produced at least 25 dB of FM receiver quieting (25 dBQ) for high communications reliability. Since this is a difficult signal level to achieve from micro satellites operating on UHF frequencies with only several watts of transmitter power, a more robust Binary Phase Shift Keying (BPSK) emission was selected for use by 1200 bps Pacsat downlink transmitters.

Binary Phase Shift Keying

Coupled with low binary data rates, Binary Phase Shift Keying has allowed interplanetary space probes to transmit vast quantities of data to ground stations on Earth from great distances with low transmitter power. BPSK offers a 6 dB signal-to-noise ratio advantage over coherent CW (CCW) modulation. CCW has long been

considered to be the premium weak signal communications mode available to amateurs.

BPSK is produced by modulating a carrier oscillator with binary modulating information in a balanced modulator. The resulting BPSK emission can be analyzed several ways, depending on whether the analysis is performed in the time domain or the frequency domain. In the time domain, the BPSK signal looks similar to the local carrier introduced to the modulator except its phase shifts by 180 degree intervals with binary modulation. In the frequency domain, BPSK looks similar to a double sideband suppressed carrier AM signal centered about its local suppressed carrier frequency.

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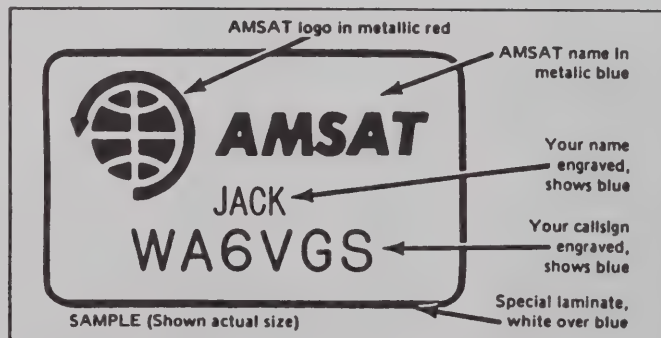
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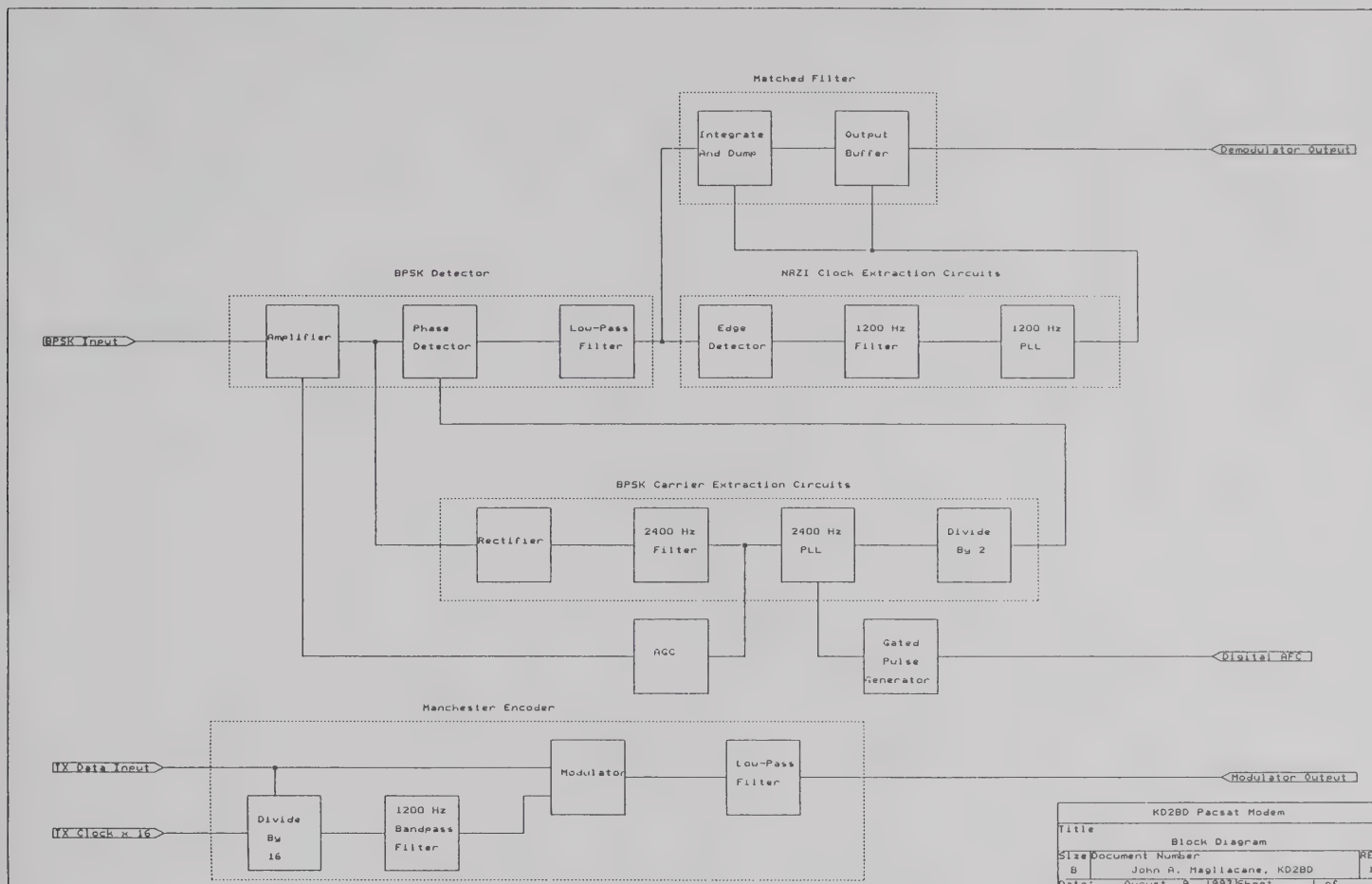


Figure 1

BPSK Signal Processing

Figure 1 is a block diagram of the KD2BD Pacsat Modem. The demodulator is designed to operate with a SSB receiver properly tuned to the frequency of a BPSK transmitter. In essence, the SSB receiver merely acts as a frequency converter, translating the RF BPSK signal captured by the ground station antenna down to the audio frequency range where it can be easily processed by the demodulator using audio circuitry.

The BPSK signal applied to the input of the modem branches in two separate directions within the demodulator. One path extracts, processes and regenerates the BPSK carrier while the second performs BPSK signal detection and filtering.

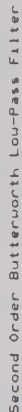
BPSK Carrier Recovery

BPSK signals in this modem design are demodulated synchronously, and synchronous detectors require a reference carrier for phase determination. Since the BPSK transmitter suppresses its carrier in its balanced-modulator, there is no clearly defined reference present in the BPSK signal. The demodulator must therefore synthesize a BPSK reference carrier from sideband components present in the composite BPSK signal. If viewed in the time domain, the carrier of a signal whose phase shifts by 180-degree intervals may be extracted by taking the absolute value of the BPSK wave-form voltage and filtering the result. A full-wave rectifier can be used to perform the absolute value function. The rectification process yields a waveform of constant phase and frequency twice that of the BPSK suppressed carrier. In the frequency domain, the rectifier may be

thought of as being a non-linear circuit that mixes the upper and lower BPSK sidebands producing the algebraic sum of those sidebands. Dividing the frequency of this product by two produces a local carrier of constant phase whose frequency equals that of the suppressed BPSK carrier.

Referring to the schematic diagram of the KD2BD Pacsat Modem shown in Figures 2, 3, and 4, the received BPSK signal is first passed through a current-variable input attenuator. Resistor R1 acts as the series element of an "L" attenuator. Diodes D1 and D2, that act as current-variable resistances form the shunt element. The AGC voltage that drives the input attenuator is derived from the filtered BPSK carrier.

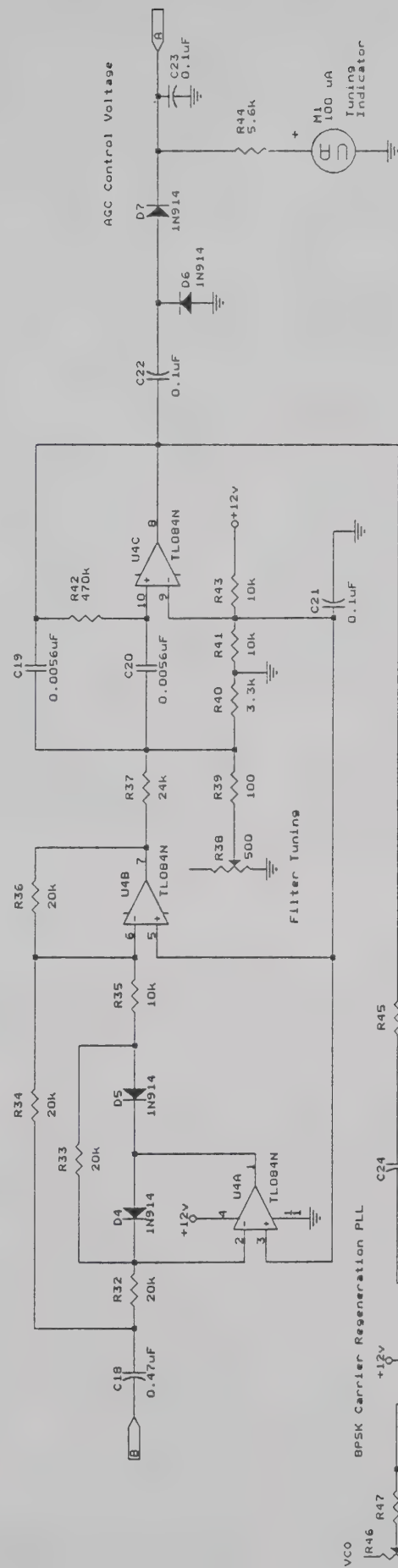
The level-controlled BPSK signal is passed through input amplifier U1A, after which it is split between the balanced phase



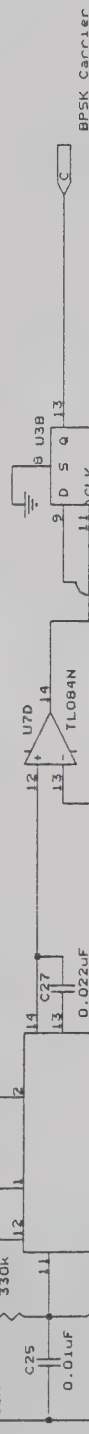
KD2BD Pacsat Modem	
Title	
BPSPK Demodulation & Clock Extraction Circuit	
RE	
Size	1
Document Number	
B	John A. Moellacane, KD2BD
Date:	November 9, 1993 Sheet 2 of

Precision Full-Wave Rectifier

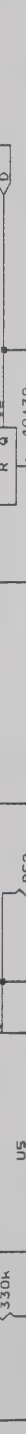
2400 Hz Bandpass Filter



Divide By Two Flip Flop



BPSK Carrier



Data Carrier Detect



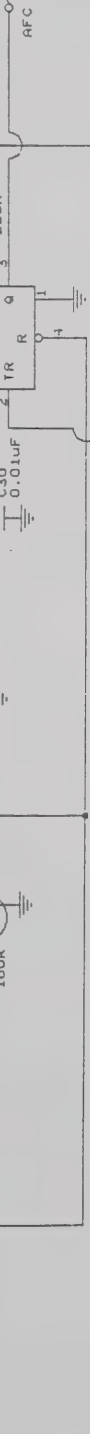
Pulse Generator



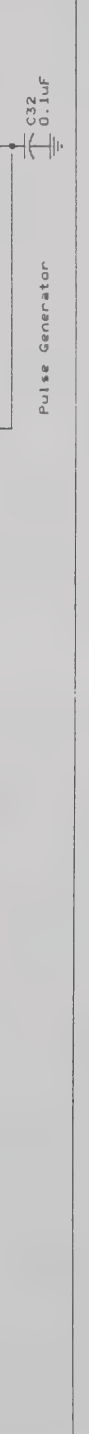
AGC Control Voltage



To Microphone Connector



To TNC



Title		KD2BD Pacsat Modem	
BPSK Carrier Extraction And AFC Circuits		RE	
Size		B	
Document Number		John A. Magliacane, KD2BD	
Date		December 5, 1993	
Sheet		3 of 3	

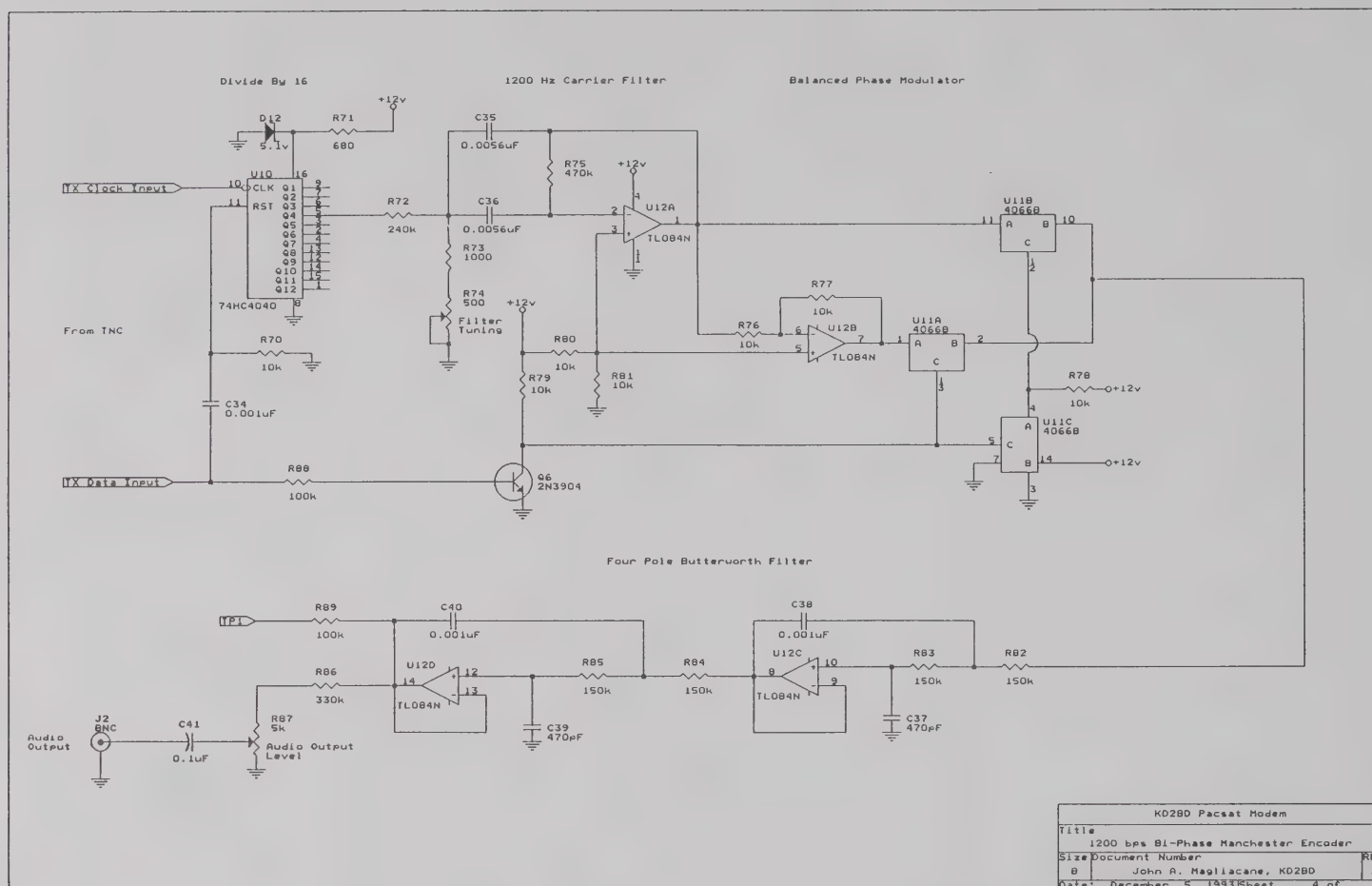


Figure 4

detector and the carrier extraction circuits. The amplified BPSK signal is processed through a precision full-wave rectifier circuit built around U4A and U4B, two sections of a TL084N quad bi-fet operational amplifier, as shown in Figure 3. The output voltage of the full-wave rectifier is the absolute value of the incoming BPSK signal. If the downlink receiver is tuned such that the BPSK suppressed carrier is at a frequency of 1200 Hz, then the output of the rectifier will contain a strong product at twice this frequency, 2400 Hz. Not only does the rectifier mix the BPSK sidebands together, but it also mixes noise components together creating even more noise energy at the rectifier output. In an effort to remove the undesired noise, the rectifier output is filtered through a narrow bandwidth bandpass filter built around op-amp U4C (see Figure 4). This filter has a center frequency of 2400 Hz, a bandwidth of 120 Hz and a Q of 20. The filtered carrier

is further processed through U5, an XR2211 Phase Locked Loop FSK Demodulator/Tone decoder circuit with a loop bandwidth of 120 Hz and a Q of 20. The result of this processing is shown in Figure 5. The XR2211 offers outstanding frequency stability and provides several output signals and other features used for receiver automatic frequency control (AFC) and data carrier detection (DCD). The Phase Locked Loop regenerates the 2400 Hz carrier, producing a noise-free waveform of constant amplitude locked in frequency and in phase with that of the BPSK carrier.

The Phase Locked Loop's oscillator is extracted from pin 14, shaped to a pulse waveform through op-amp U7D, and applied to U3B, a "D" flip flop configured as a frequency divider. Toggling on the rising edge of each input pulse, the flip flop divides the frequency of the PLL oscillator

by two, reproducing the 1200 Hz BPSK carrier with a 50 percent duty cycle as required for proper operation of the phase detector.

The output of the 2400 Hz bandpass filter is also passed through a half-wave peak voltage doubler and filter to generate a DC control voltage for the automatic gain control system. Deriving the control voltage from the filtered BPSK carrier results in an AGC that is virtually immune to noise and interference that could otherwise affect the AGC and lead to demodulator desense. The AGC control voltage also drives a front panel tuning and signal strength meter.

BPSK Signal Detection

The second path the received BPSK signal takes is the one that actually extracts intelligence from the BPSK signal. A

non-limiting, balanced linear phase detector composed of operational amplifier U1B and CMOS switches U9B and U9C is used to translate the BPSK input signal down to baseband levels. The phase detector is driven by the locally generated BPSK carrier supplied by U3B, and offers high local carrier suppression and does not distort the wave shape of the BPSK signal. It also helps to remove noise and other interference not in phase with the desired BPSK signal.

In this design, linear AGC is used rather than hard limiting to maintain a constant output voltage from the detector. As a result, strong input noise does not corrupt weak BPSK signals since there is no limiter or associated "capture effect" to suppress the weaker signal. Since the phase detector switches at the zero crossing point of the sinusoidal BPSK waveform, the detrimental effects of phase jitter and transmitted phase noise are minimized.

The output of the phase detector is gently filtered through a second-order Butterworth low-pass filter to remove high-order products generated by the coherent demodulation process. The frequency response of the filter loosely approximates that of the transmitted BPSK spectrum, and its smoothed output voltage is a function of how well the phase of the BPSK signal correlates with that of the

locally generated carrier. A perfect correlation produces a maximum output voltage of one polarity while a correlation of opposite phase produces an output voltage of opposite polarity.

NRZI Data Encoding

The AX.25 packet radio communication protocol use a data encoding technique known as NRZI (Non Return to Zero Inverted). NRZI synchronous data encoding packs both data and clock information into one binary serial data stream. An NRZI receiver is edge triggered rather than level triggered, and must therefore be sensitive to logic level transitions to extract clock and data information from those transmissions. With NRZI, a '0' data bit is encoded as a bit level transition, while a '1' is encoded as no transition. The AX.25 protocol uses a process called zero insertion or "bit stuffing" that ensures that no more than five '1's can occur sequentially except when flag bytes are transmitted. Flags are used to identify the beginning and ending of each packet frame.

Zero insertion in combination with NRZI encoding guarantees that a logic level transition occurs at least once every five bit periods. These frequent level transitions are necessary to allow the modem and TNC

to synchronize with the transmitting TNC's clock.

Post Detection Filtering

In order to achieve the maximum demodulator performance possible, the detected NRZI-encoded serial data stream must be filtered to remove as much noise as possible without introducing distortion that could lead to data corruption. The detected baseband NRZI serial data stream present after the Butterworth filter branches in two separate paths. One branch extracts and regenerates the 1200 Hz bit clock from the NRZI encoded data stream, while the other filters the NRZI data through an "integrate and dump" processor that forms a matched output filter.

Bit Clock Regeneration

The unprocessed NRZI encoded serial data stream from the detector is shaped to a square wave of constant amplitude through op-amp U7A and further buffered through exclusive-OR gate U2B. The NRZI data is then fed through an edge detector to extract clock pulses from the detected waveform. The edge detector acts as a frequency doubler by multiplying the NRZI serial data stream by itself delayed by one half of a bit period. The RC network composed of R11 and C7 provides a one half-bit delay, while

RECT Temperature= 27
T in M

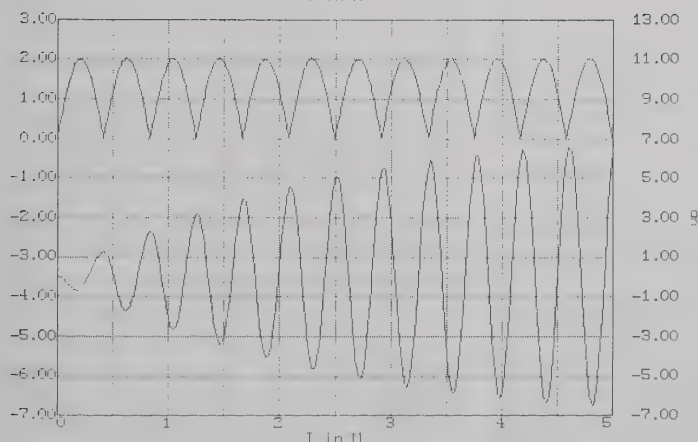


Figure 5

FILTER Temperature= 27
T in M

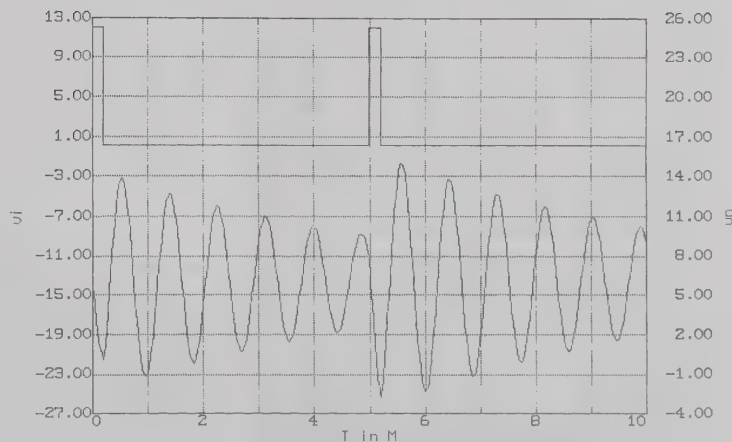


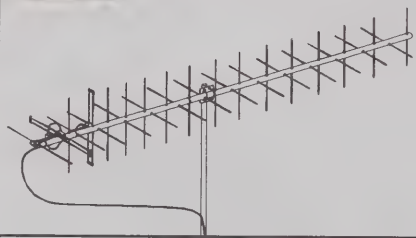
Figure 6

exclusive-OR gate U2A performs the multiplication. The edge detector produces an output pulse for every NRZI logic level transition received. These pulses are in phase with the embedded NRZI clock signal and are filtered by a 1200 Hz narrow bandpass filter, U1D. This filter receives excitation from the edge detector and produces a damped sine wave by virtue of its high 'Q' and the "flywheel effect". Its purpose is to use stored energy to fill in the gaps during periods when NRZI bit transitions do not occur and clock pulses cannot be recovered from the edge detector. This effect is shown in Figure 6. The damped sine wave output of this filter feeds U8, an XR2211 PLL with a center frequency of 1200 Hz and a loop bandwidth of 15 Hz. The phase locked loop follows the average phase and frequency of the filtered NRZI clock pulses, and provides precise timing signals required for operating the "integrate and dump" processor.

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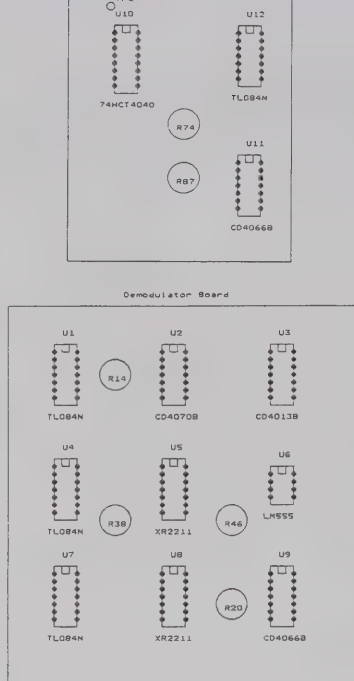


Figure 7

ratio (SNR) is achieved in a communications system when the bandpass of a receiver exactly matches the bandwidth of the transmitted signal. In order to achieve maximum signal-to-noise ratio, the post detection filtering in this modem is performed with a filter matched to the AX.25 binary data rate of 1200 bps. Unlike simple RC or LC filters, the integrate and dump processor operates in the time domain and is implemented with a resettable integrator and an output latch driven by 1200 Hz clock pulses recovered from the 1200 bps NRZI encoded data stream. With a matched filter, the demodulator's output signal-to-noise ratio is dependent not on the received signal-to-noise ratio, but rather on the ratio of the signal energy to the power spectral density of the noise at the filter's input. A matched filter allows the successful recovery of weak signals buried deep in wideband noise, and offers the smallest error probability that can be achieved and the best bit error rate performance possible over an additive white Gaussian noise channel.

The unprocessed NRZI serial data stream from the phase detector is integrated over each bit interval and the result is sampled by an output latch. During each bit interval, random noise energy will accumulate no charge across integration capacitor C17, while an input signal coherent with the demodulator's internal BPSK reference carrier will accumulate a charge either above or below this point, depending on its phase. After

approximately 90 percent of the bit interval has passed, the voltage integrated over this period is sampled and evaluated by comparing it to the reference voltage equal to half the supply voltage. Operational amplifier U7B, operating as a voltage comparator, performs this evaluation. The result is sampled and latched by U3A, the CD4013B output buffer. If the integrated voltage is above the +1/2 Vcc reference, the output buffer latches to a logic level 1. If it is below this level, the CD4013B buffer outputs a 0.

Shortly after the output has latched, the integrator capacitor is discharged and the process repeats for the next data bit. This time averaging process of integrating, sampling, latching, and dumping produces a well-filtered serial data stream re-timed to the recovered NRZI clock signal. The output of matched filter is then converted to TTL levels of 0 and +5 volts through transistor Q1 and made available for processing by the terminal node controller.

Handshaking Controls

U5, the XR2211 phase locked loop used for BPSK carrier regeneration contains an "in-phase" (I channel) detector to indicate whether or not the PLL is locked in frequency and phase with its input signal. Since the PLL's input in this case is a product of the BPSK carrier, the "in-phase" detector indicates the presence or absence of a valid BPSK carrier on the modem's input. U8, the XR2211 PLL used for bit clock regeneration contains a similar "in-phase" detector. In this case, the detector indicates the presence of valid 1200 bit per second clock pulses extracted from the BPSK input signal. The active low, open collector outputs of both these detectors are combined by connecting their outputs together. This combined output is pulled to ground level when no carrier and no clock pulses are detected, and to +5 volts when both a carrier and a 1200 bps clock stream are present. It is buffered by Q4 to drive LED indicator D10 and is made available to the TNC as a data carrier detect (DCD) control signal on the output of the modem. The DCD line connects to the TNC serial I/O circuits and provides for on-the-air flow control and protocol timing. The use of combined carrier and clock detection results in a DCD that is very immune to noise and triggering from false signals.

Automatic Frequency Control

Radio links between satellites and ground stations experience Doppler effects due to satellite motion and the Earth's rotation. For an amateur radio spacecraft in a low-Earth orbit of about 1000 km transmitting on UHF, the magnitude of Doppler shift can be as much as 20 kHz, with a maximum rate of change of 40 Hz per second at the time of closest approach on an overhead pass. With the BPSK demodulator designed for a signal properly tuned to within a few tens of Hertz, it is necessary to use an automatic frequency control system to keep the downlink receiver properly tuned to a BPSK transmission during a satellite pass.

An internal voltage comparator in U5 that is normally used for FSK decoder applications of the XR2211 controls the logic of the Automatic Frequency Control circuitry. The comparator compares the PLL error voltage to a reference within the chip. If the error voltage exceeds limits dictated by the PLL's loop bandwidth, it is an indication that the BPSK signal is not properly in tune and the AFC circuitry is activated to affect a correction. If the signal is tuned too high in frequency, the comparator output voltage at pin 7 is pulled low, but only if a valid BPSK carrier is detected on the input of the modem. If the voltage at pin 7 goes low, it allows the LM555 gated oscillator to run stepping the downlink receiver lower in frequency to compensate for the Doppler shift. The receiver frequency is controlled through a connection available on the transceiver's microphone connector. Once the receiver frequency has been corrected, the comparator output voltage pin 7 returns high, disabling the LM555 oscillator and keeping the receiver's frequency fixed until the next correction is required.

Note that the AFC circuit in this modem can tune the receiver in one direction only. Since the Doppler effect causes the signal received from satellites in Earth orbit to drift lower in frequency during a pass and never higher, it is only necessary to have the receiver tune lower in frequency to compensate for the motion of the satellite. Front panel switch SW1 allows the operator to disable the AFC feature of the modem during manual receiver tuning.

Two digital AFC pulse polarities are produced by the modem. Output "AFC +"

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produces a positive output voltage with respect to ground every time the ground station receiver must be tuned. This polarity is consistent with that required for Yaesu FT-726R transceiver tuning.

Others require a switch to ground, as provided by the "AFC -" output.

The ground station receiver must be capable of tuning in 20 Hz increments or less. If this is not possible, then it will be necessary to use an analog AFC approach whereby the modem controls the voltage applied across a varactor diode associated with the receiver's VFO.

Data Modulation

Full access to the digital transponders on the Pacsat satellites requires that ground stations use 1200 bps 3.5 kHz deviation Bi-Phase Manchester encoded Frequency Shift Keying (FSK) for their uplink transmissions. This is produced by feeding Manchester encoded binary data into the microphone connector of a standard

2-meter narrow-band FM voice transmitter. The KD2BD Pacsat Modem produces Manchester code by modulating the 1200 Hz clock derived from the TNC with the 1200 bps transmit data in a balanced phase modulator. The output is then filtered to produce a clean output waveform that is low in harmonic distortion.

The TX clock available from the TNC modem disconnect header is at 16 times the transmitted data rate, or 19,200 Hz for 1200 bit per second data. The modulator divides this clock signal by 16 and combines it with the transmit data in a phase modulator to produce a Manchester encoded data stream. U10, a 74HC4040 ripple counter provides the necessary frequency division. The divider is reset on the rising edge of the transmit data waveform through R70 and C34 that form a differentiator network. This synchronization keeps the divided clock waveform in proper phase with the transmit data, and keeps the modulation switching transients at the zero crossing points of the carrier waveform for minimum harmonic distortion. The 1200 Hz square wave from

the divider is then filtered through a 1200 Hz bandpass filter designed around operational amplifier U12A to produce a low-distortion sinusoidal waveform. The 1200 Hz carrier is modulated by the transmit data from the TNC and the result is passed through a fourth-order Butterworth low-pass filter. The purpose of the low-pass filter is to reduce the sideband components of the output spectrum that are a result of BPSK modulation. The Butterworth filter provides an almost constant group delay across the entire modulator bandwidth, and this results in an output waveform having minimal zero crossing point dispersion and phase jitter with modulation.

Alignment And Testing

Initial alignment of the KD2BD Pacsat Modem requires the use of a high impedance voltmeter and an oscilloscope. The modem should be connected to the host TNC so an audio loop back test between modulator and demodulator sections can be performed..

Set all potentiometers to their center positions. Configure the TNC for a radio data rate of 1200 baud, and connect the TX Clock and ground from the TNC to the modem and apply power to both the modem and the TNC. Connect the oscilloscope to the modulator's high-level audio output found at Test Point 1 (TP1) and verify the existence of a 1200 Hz sinusoidal pattern on the oscilloscope. Adjust R74 (500 Ohms) associated with the bandpass filter in the modulator for maximum sine wave amplitude.

Connect TP1 to the audio input of the demodulator. Adjust the 2400 Hz filter tuning adjustment potentiometer R38 (500 Ohms) until the tuning meter, M1, achieves maximum upscale deflection. With a DC voltmeter connected between pins 10 and 11 of U5 (XR2211), adjust R46 (10 kOhms) until the voltmeter reads zero volts. A 12 volt peak-to-peak, 1200 Hz square wave should be present on pins 12 and 13 of U3B (CD4013B).

Attach the TX Data line from the TNC to the modem. The TNC produces a series of AX.25 "flags" in its unconnected state that is sufficient for testing the clock extraction and regeneration circuitry of the modem. Using the oscilloscope, verify the presence of a pulse train on pin 3 of U2A

(CD4070B). A damped sine wave should be present on U1D pin 14 (TL084N). Adjust potentiometer R14 (500 Ohms) for maximum sinewave amplitude as seen on the oscilloscope. With a dc voltmeter connected between pins 10 and 11 of U5 (XR2211), adjust potentiometer R2 (5 kOhms) for a reading of zero volts. At this point, the DCD indicator should be off. Trigger the oscilloscope's internal horizontal sweep to the recovered clock pulses present on pin 14 of U4D (TL084N). Monitor the waveform present on pin 8 of U7C (TL084N) and re-adjust potentiometer R14 for the tallest and cleanest pattern of right triangles seen on the oscilloscope. An "eye diagram" can be viewed by monitoring the waveform on pin 8 of U1C (TL084N) while triggering on U4D pin 14.

At this point, the modem is fully aligned and is ready for operation. You

should be able to establish a packet connection with yourself at the keyboard as a verification that both modulator and demodulator sections of the modem are functioning properly.

Modem Operation

The KD2BD Pacsat Modem requires several connections to the host TNC as well as the ground station radio equipment. Connections to the TNC's internal modem must first be broken so the following connections to the pacsat modem can be made. Received data from the modem is directed to the TNC via the modem disconnect header available on many terminal node controllers. RX Data from the modem is connected to pin 17. DCD logic from the modem connects to pin 1. Transmit data from the TNC connects to the modem via pin 19, and the transmitter clock

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(x16) from the TNC attaches to the modem through pin 12. Figure 7 shows the connections for a TAPR TNC-s or TNC-2 clone. Consult your owner's manual for the specifics of connecting an external modem to your TNC.

Connections must also be made so the TNC can key the uplink transmitter. Modulator audio from the modem connects to the microphone connector of the uplink transmitter. AFC pulses from the modem trigger the downlink receiver tuning, and simulate a user pressing the microphone's "down" frequency button. Audio from the receiver connects to the modem's audio input. As with the TNC, consult the owner's manuals of your ground station radio equipment before making any connections to the modem.

Once connections between the modem, TNC, and ground station radio equipment have been made, on-the-air operation can begin. With the modem's AFC switch in the off position and the receiver in the USB mode, tune in a satellite transmitting 1200 bps BPSK. Slowly tune across the BPSK signal until the tuning meter achieves maximum upscale deflection. The tuning meter will indicate several peaks when tuning across a BPSK signal. Correct tuning is achieved when the receiver is tuned to the center of the highest peak. When properly done, the yellow DCD indicator should be on and you should be able to copy packets from the satellite on your computer terminal. Switch the AFC on to activate the modem's automatic frequency control. As the red AFC indicator comes on, the receiver should tune lower in frequency in compensation for Doppler shift. The KD2BD Pacsat Modem is very sensitive and will successfully track BPSK signals barely audible through receiver noise.

Potentiometer R87 (5 kOhms) should be adjusted for a modem output audio level that produces approximately 3.5 kHz peak carrier deviation of the uplink transmitter. Greater levels of modulation will cause the uplink signal to deviate right out of the 15 kHz-wide Pacsat uplink receiver passband.

To communicate with the satellite, adjust your uplink transmitter to one of the transponder uplink frequencies and set your TNC for full-duplex communications (FULLDUP ON). Sending a connect request should result in a connection to the satellite. The actual procedure for

communicating with the satellite's mailbox will depend on the Pacsat being accessed and the ground station terminal software required for access. FO-20 operates in a fashion similar to a typical terrestrial packet bulletin board running PRMBS software and can be accessed without the need of Pacsat terminal software, such as "PB". [Editor's Note: FO-20 is not currently operational in its digital mode.]

Reception of WEBERSAT-OSCAR-18's CCD Earth images does not require the use of an uplink transmitter or the modulator portion of this modem, but does require the use of Microsat ground station software and WEBERSAT image display software. The AMSAT-NA Digital Satellite Guide, containing Microsat Ground Station software, and "Weberware" for use with OSCAR-18 are available from AMSAT-NA, 850 Sligo Avenue, Silver Spring, Maryland 20910.

Summary

The KD2BD Pacsat Modem was designed independently without the luxury of having seen other previously published Pacsat modem designs. It is the result of countless hours of research, experimentation, and testing. Many different modem configurations were attempted over the design period with the one described here providing the best overall performance. One of the major design goals of this modem was to produce a modem capable of demodulating very weak signals. The performance demonstrated with this modem shows these design goals have clearly been met.

So whether your interests are in viewing the world through the eyes of WEBERSAT, setting up an electronic mail gateway with PACSAT, or just reading the latest issue of SpaceNews on OSCAR-20, you will find the KD2BD Pacsat Modem is a valuable accessory for your TNC and a welcomed addition to your OSCAR satellite ground station.

See you on the birds!

SK DE KD2BD

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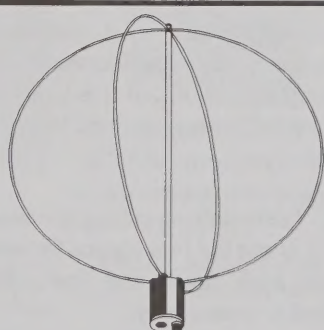
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Amateur Satellite Links in the Two-Meter Band: Is it time to say goodbye?

Antonio F. Fernandez MD, EA4LE
Internet: ea4le@amsat.org

Editor's note: Dr. Fernandez provides readers with an interesting commentary on the problems of two-meter band satellite use. This interesting perspective into two-meter band operations expresses some of the challenges that face many satellite operators in other parts of the world.

Summary

Since the very beginning of the amateur space program almost every amateur satellite has used the two-meter band for downlink or uplink. Albeit there is no discussion on the proven usefulness of the band in the past, there are three reasons, in the author's opinion, to seriously limit the use of the two meter band in the future amateur satellites:

1. Nowadays, the band is overcrowded in many areas of the globe and the satellite sub-band is often used by intruders or unlicensed stations. Thus, interference to the amateur satellite service on this band is currently a problem and it is likely that the situation will become even worse in the future.

2. Technically speaking the two-meter band it is not the best choice for downlink due to high noise and the equipment required to overcome it.

3. In future satellites, we should foster the use of the microwave bands as an alternative (to other bands like the two-meter band) in the satellites to come. This would not only keep up with the pace of communications technology development and the experimental nature of our hobby, but will help us to preserve the segments allocated by the WARC to the Amateur Radio Service in these bands.

QRM on the Two-Meter Satellite Sub-Band

On December 12, 1961 when the Space Age was only four years old, OSCAR I was launched into orbit and the first signals

from the first Amateur Satellite were transmitted in the two-meter (145 MHz) band.

Since then almost every Amateur Satellite has successfully used the two-meter band for uplink or downlink. Meanwhile on the ground, the two-meter band has been heavily populated by terrestrial (in opposition to satellite) operators all over the world. This has been especially true since the early seventies with the introduction of FM mode and repeaters. This increasing use of the two-meter band has led to it becoming one of the most attractive market segment for makers of Amateur Radio equipment. Together with volume of scale, this has made the price of two meter rigs relatively inexpensive in comparison to equipment intended for other bands, the later in turn has favored the popularity of the two-meter band. In large urban areas the two-meter band has become very crowded and the situation is even more severe in the regions of the world when the available bandwidth is just 2 MHz (144-146 MHz). Unfortunately, FM operation in the two meter band it is not only attractive for amateur radio, but also for unlicensed stations. In most parts of the world Amateur Radio equipment is sold to anyone, licensed operator or not, and it's an inexpensive way to obtain professional quality communications equipment. This is why non-amateur radio operators purchase two-meter transceivers for different and some times bizarre purposes. For example, taxi drivers in Spain, hunters in the United States, 'hookers' in Mexico, and many other unidentified users in many parts of the world have illegally used the two-meter band.

This heavy use of the two-meter band easily leads to harmful interference in the satellite segment of the band. Operating mode B on AO-10 or AO-13 at my QTH (25 km northwest from downtown Madrid, Spain) has become a nightmare. Take for instance a 10 watts local FM signal from an intruder or unlicensed station. The QRM that is generated can easily blank most of the transponder downlink bandwidth, especially when you are using very sensitive equipment (i.e. GaAsFET preamps) to receive weak signals from the satellite.

Until recently this has been a local problem restricted to some areas, as is my

case, but with the launch of satellites with 'hot receivers' in the two-meter band, as is the case of AO-27, the local problem has become an international issue. AO-27 has a FM uplink on 145.850 MHz and a corresponding downlink on 436.800 MHz. AO-27's receiver is very sensitive and reports suggest that you can uplink to it even with a handie-talkie and a rubber duck antenna. Soon after AO-27 was put into Amateur Radio Service improper use of the satellite uplink frequency was noted. OZ7MY, a Danish ham, reported three different 'disturbances' during a time when AO-27 was in Amateur Radio use most of the week (Christoffersen). The report includes Spanish speaking voices when Spain was in AO-27's footprint, Scandinavian voices when the footprint was in northern Europe, and children speaking, what the reporter thought was Arabic, when the AO-27 was over the Middle East. These reports were confirmed by others in Europe including G3IOR and DJ0MY (Oliver). A similar situation has been observed from the United States when a colleague from California informed me that he can hear voices, probably from a Caribbean or Latin American stations on the AO-27 downlink.

In the case of the Spanish voices heard in Europe, there is no doubt that they could be taxi drivers illegally operating in the band (145.850 MHz is their favorite frequency) and even licensed radio amateurs (terrestrial users). The Spanish Radio Amateur Association, (URE) and numerous other radio amateurs on their own, have reported these law violations by non-amateurs and improper use of the band by licensed amateurs to authorities with little or no success at all. It seems that the authorities do not make the necessary effort to keep the bands clean. In that sense I think that abuse of the two meter band is comparable to crime in every major city around the globe; it is difficult to control, even with a lot of resources.

Voice interferences in the two-meter band not only affect voice transponders, as is the case of AO-27, they are also an inconvenience for digital satellite users. Strong FM signals track the receiver's AFC of satellites like UO-22 and KO-23 competing with the digital uplink.

Noise in the Two-Meter Band

The noise issue in the two-meter band has been brilliantly addressed by James Miller, G3RUH, in an article that's worth reading, and if you have not, I encourage you to do so (Miller). A copy of the article is available for downloading from the Internet AMSAT FTP site.

Secure Our Allocations in the Microwave Bands

The microwave band segments that were assigned to the Amateur Radio Service in WARC-79 are one of most valuable assets we have in the RF spectrum and constitute the basis for the future development and expansion of our hobby (Summer). These bands are secondary allocations, with the exception of the 6-cm band (5 GHz), meaning that we can use them unless we produce harmful interference to the primary users (Wilson). However, many non-amateur radio organizations are looking for space in the RF spectrum for their own activities and if our bands are not used there is the possibility that we can lose them in favor of other services. The amateur radio community was successful at WARC-92 in keeping their privileges in the microwave bands but the best way to secure them is by using them (Sumner).

Microwaves are particularly well suited for Amateur Satellite operation, so we have a very good opportunity to start using them with Phase 3D. I know there is controversy in this issue and that many people were disappointed when they discovered that Phase 3D might not carry a VHF transmitter. AMSAT-UK and Mike Dorsett, G6GEJ have made a tremendous effort to have a VHF transmitter on time for the Phase 3D launch (Dorsett). I think that we should be very grateful to them as with mode UV many former mode B stations can now get their feet wet with our new supersatellite. But, in my opinion, the schedule should favor other modes and not mode UV.

Conclusions

To date, the two-meter band is been the most used by Amateur Satellites. Currently the band is overcrowded in many parts of the world and it's difficult to control the improper use of the band. As a result of this

situation, there are interferences to Amateur Satellite Service. In addition, in comparison with the microwave bands, the two-meter band is quite noisy making it very inefficient by today's standards. The use of microwave bands and the progressive abandoning of the two-meter band will allow us to progress and will contribute to securing the allocations of this valuable RF segments for the amateur community. Phase 3D could be the benchmark to put this in practice.

Acknowledgments

The idea for writing this article came from Andy Reynolds, WD9IYT, an *AMSAT Journal* Editor, who initiated discussion about pirated hamsat frequencies on the AMSAT-BB.

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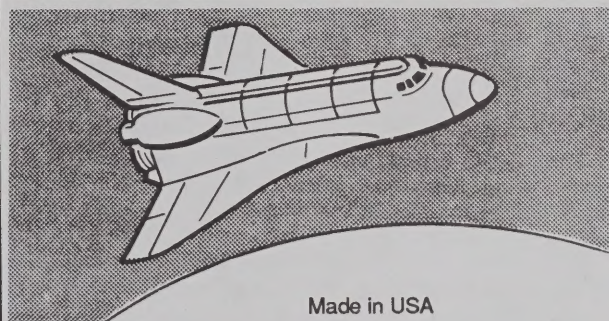
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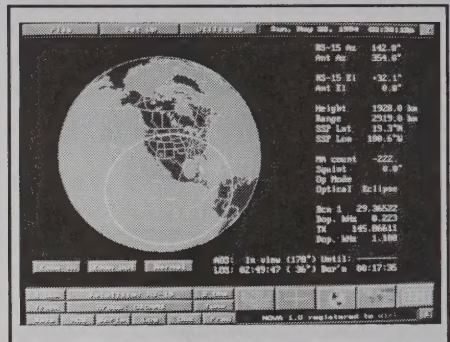
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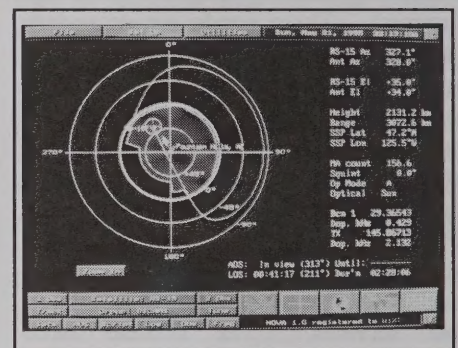
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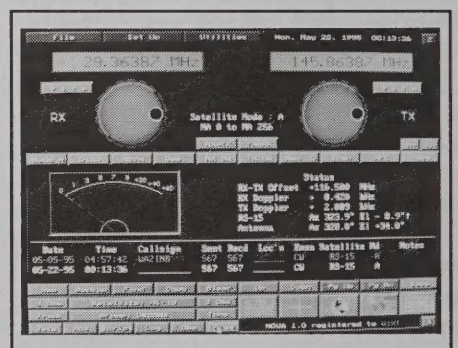


Radar position and tracking

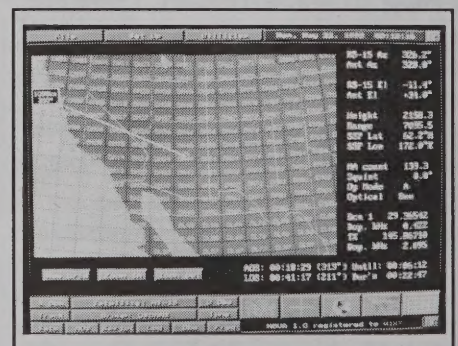
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